SOLVED PAPERS 2021

NEET | JEE SESSION-4 Main

www.mtg.in | October 2021 | Pages 80 | ₹ 40

Class XI-XII CBSE warm up! TERM-I

CHEMISTRY today

India's #1
CHEMISTRY MONTHLY FOR
JEE (Main & Advanced) & NEET

MONTHLY TEST DRIVE

CLASS XI & XII

LEARN FAST

mtG
Trust of more than
1 Crore Readers
Since 1982

2021100013105

CONCEPT MAP

BRUSH UP *for* Class XI-XII
NEET / JEE

ALLEN Career Institute : JEE Main 2021 Result

Saluting the Hardwork, Dedication and Excellence of ALLENites

Every year ALLENites are consistently proving their excellence, but this year they succeeded against all odds. While everyone was trying to cope with the new normal, ALLENites turned all the adversities into opportunities by trusting ALLEN's 33 Years of Success Legacy . **We Salute their Dedication & Self-Belief.**

ANSHUL VERMA
CLASSROOM COURSE
RAJASTHAN TOPPER

GURAMRIT SINGH
CLASSROOM COURSE
CHANDIGARH TOPPER

KAVYA CHOPRA
CLASSROOM COURSE
DELHI (NCT) TOPPER

MRIDUL AGARWAL
CLASSROOM COURSE
RAJASTHAN TOPPER

PULKIT GOYAL
CLASSROOM COURSE
PUNJAB TOPPER

SIDDHANT MUKHERJEE
CLASSROOM COURSE
RAJASTHAN TOPPER

✓ **13 Students Scored 100%ile** | **43 in Top 100 All India Ranks** | ✓ **298 in Top 1000 AIR**

AIR-7	AIR-8	AIR-10	AIR-14	AIR-21	AIR-22	AIR-23
						
RAJASTHAN TOPPER	PUNJAB TOPPER	GUJARAT TOPPER	MAHARASHTRA TOPPER	RAJASTHAN TOPPER	MAHARASHTRA TOPPER	RAJASTHAN TOPPER
ZENITH MALHOTRA Classroom Course	**PRATHAM GARG** Distance Course	**ANANTH K. KIDAMBI** Classroom Course	**KULKARNI SOURABH S.** Distance Course	**ROHIT KUMAR** Classroom Course	**AMEYA P. DESHMUKH** Classroom Course	**SAKET JHA** Classroom Course

17444 **ALLEN Students Eligible for JEE (Adv.) 2021**

CCP : 10298
DLP : 7146

✓ **18 State Toppers are ALLEN Students**

✓ **293 Scored 100%ile in Individual Subjects**

Authenticity of Result : Power of **ALLEN**

Admission Open Session 2021-22 :

ALLEN's Blended (Online+Offline) / Online Coaching Program

JEE (Main+Adv.) | JEE (Main) | NEET (UG)

NTSE | OLYMPIADS | PNCF | Class 6th to 12th & 12th Pass / Repeaters

GLOBAL STUDIES | EARLY CHILDHOOD DEVELOPMENT (Class HKG to 8th)

For Admission Scholarship Test, Early Fee Benefits, Course & Admission Process, logon to **www.allen.ac.in** or Call **0744-2757575**

ALLEN® CAREER INSTITUTE KOTA (RAJASTHAN) — path to success

Corporate Office:
"SANKALP", CP-6, Indra Vihar, Kota (Raj.)
Tel: 0744-2757575, 3556677 | Whatsapp: 0744-2757700 | Web: www.allen.ac.in

CHEMISTRY today

Volume 30 No. 10 October 2021

Managing Editor
Mahabir Singh

Editor
Anil Ahlawat

Corporate Office:
Plot 99, Sector 44 Institutional area, Gurugram -122 003 (HR).
Tel : 0124-6601200 e-mail : info@mtg.in website : www.mtg.in

Regd. Office:
406, Taj Apartment, Near Safdarjung Hospital, New Delhi - 110029.

CONTENTS

Printed and Published by Mahabir Singh on behalf of MTG Learning Media Pvt. Ltd. Printed at HT Media Ltd., B-2, Sector-63, Noida, UP-201307 and published at 406, Taj Apartment, Ring Road, Near Safdarjung Hospital, New Delhi - 110029.
Editor : Anil Ahlawat

NEET

SOLVED PAPER 2021

Hurray!! We are happy to inform our readers that out of the 50 questions asked in NEET 2021, more than 90% questions were either exactly same or of similar type from the **MTG Books.** Hurray!!

Here, the references of few are given :

Exam Q. No.	MTG Book	Q. No.	P. No.
1	NEET Champion (XI)	80	13
2	33 Years NEET (XII)	61	58
3	Fingertips (XI)	11	139
4	Fingertips (XII)	73	153
5	NEET Guide (XI)	48	159
6	NEET Guide (XI)	16	287
8	NEET Champion (XI)	83	254
9	NEET Champion (XI)	135	64
10	NEET Champion (XII)	55	219
11	NEET Champion (XII)	112	320
12	33 Years NEET (XII)	37	19
15	NEET Guide (XI)	11	326
17	NEET Guide (XI)	129	42
18	NEET Champion (XI)	116	139
19	NEET Guide (XII)	96	41
22	Fingertips (XII)	81	117

and more such questions .....

SECTION - A

1. Right option for the number of tetrahedral and octahedral voids in hexagonal primitive unit cell are

(a) 12, 6 (b) 8, 4

(c) 6, 12 (d) 2, 1

2. Zr ($Z = 40$) and Hf ($Z = 72$) have similar atomic and ionic radii because of

(a) having similar chemical properties

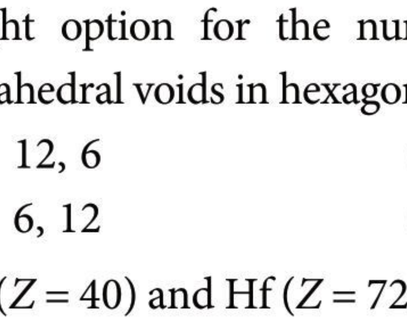
(b) belonging to same group

(c) diagonal relationship

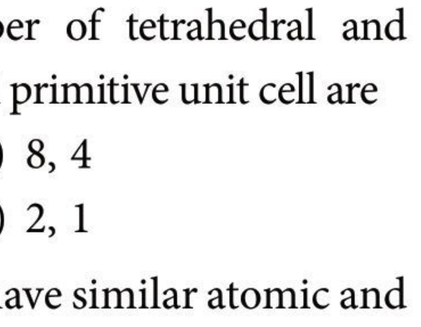
(d) lanthanoid contraction.

3. Choose the correct option for graphical representation of Boyle's law, which shows a graph of pressure *vs* volume of a gas at different temperatures.

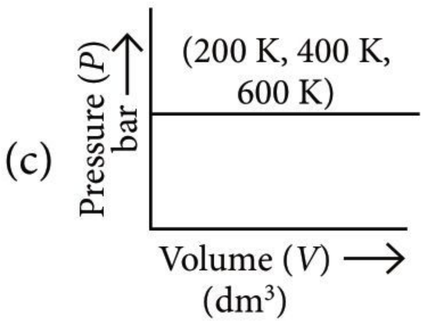
(a)



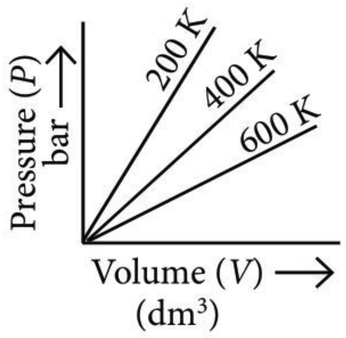
(b)



(c)



(d)



4. The right option for the statement "Tyndall effect is exhibited by" is

(a) urea solution (b) NaCl solution

(c) glucose solution (d) starch solution.

5. Which one among the following is the correct option for right relationship between C_P and C_V for one mole of ideal gas?

(a) $C_V = RC_P$ (b) $C_P + C_V = R$

(c) $C_P - C_V = R$ (d) $C_P = RC_V$

6. The structures of beryllium chloride in solid state and vapour phase are

(a) chain in both

(b) chain and dimer, respectively

(c) linear in both

(d) dimer and linear, respectively.

7. Tritium a radioactive isotope of hydrogen, emits which of the following particles?
(a) Neutron (n) (b) Beta(β^-)
(c) Alpha (α) (d) Gamma(γ)

8. The major product formed in dehydrohalogenation reaction of 2-bromo pentane is pent-2-ene. This product formation is based on?
(a) Huckel's Rule (b) Saytzeff's Rule
(c) Hund's Rule (d) Hofmann Rule

9. BF_3 is planar and electron deficient compound. Hybridization and number of electrons around the central atom, respectively are
(a) sp^2 and 8 (b) sp^3 and 4
(c) sp^3 and 6 (d) sp^2 and 6

10. What is the IUPAC name of the organic compound formed in the following chemical reaction?

$$\text{Acetone} \xrightarrow[\text{(ii) } H_2O, H^+]{\text{(i) } C_2H_5MgBr, \text{ dry ether}} \text{Product}$$

(a) 2-Methylbutan-2-ol
(b) 2-Methylpropan-2-ol
(c) Pentan-2-ol (d) Pentan-3-ol

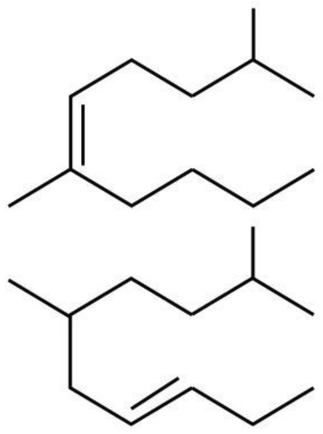
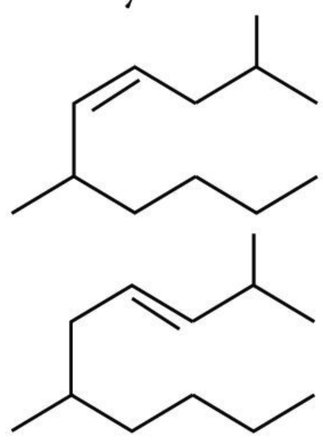
11. The RBC deficiency is deficiency disease of
(a) vitamin B_2 (b) vitamin B_{12}
(c) vitamin B_6 (d) vitamin B_1.

12. The molar conductance of NaCl, HCl and CH_3COONa at infinite dilution are 126.45, 426.16 and 91.0 S cm^2 mol^{-1} respectively. The molar conductance of CH_3COOH at infinite dilution is. Choose the right option for your answer.
(a) 540.48 S cm^2 mol^{-1} (b) 201.28 S cm^2 mol^{-1}
(c) 390.71 S cm^2 mol^{-1} (d) 698.28 S cm^2 mol^{-1}

13. The incorrect statement among the following is
(a) actinoids are highly reactive metals, especially when finely divided
(b) actinoid contraction is greater for element to element than lanthanoid contraction
(c) most of the trivalent lanthanoid ions are colorless in the solid state
(d) lanthanoids are good conductors of heat and electricity.

14. **Statement I :** Acid strength increases in the order given as HF << HCl << HBr << HI.
Statement II : As the size of the elements F, Cl, Br, I increases down the group the bond strength of HF, HCl, HBr, and HI decreases and so the acid strength increases.
In the light of the above statements, choose the correct answer from the options given below.
(a) Statement I is incorrect but statement II is true.
(b) Both statement I and statement II are true.
(c) Both statement I and statement II are false.
(d) Statement I is correct but statement II is false.

15. The correct structure of 2, 6-dimethyl-dec-4-ene is

(a) 
(b) 
(c)
(d)

16. The correct sequence of bond enthalpy of '$C - X$' bond is
(a) $CH_3 - Cl > CH_3 - F > CH_3 - Br > CH_3 - I$
(b) $CH_3 - F < CH_3 - Cl < CH_3 - Br < CH_3 - I$
(c) $CH_3 - F > CH_3 - Cl > CH_3 - Br > CH_3 - I$
(d) $CH_3 - F < CH_3 - Cl > CH_3 - Br > CH_3 - I$

17. A particular station of All India Radio, New Delhi, broadcasts on a frequency of 1,368 kHz (kilohertz). The wavelength of the electromagnetic radiation emitted by the transmitter is [speed of light, $c = 3.0 \times 10^8$ m s^{-1}]
(a) 21.92 cm (b) 219.3 m
(c) 219.2 m (d) 2192 m

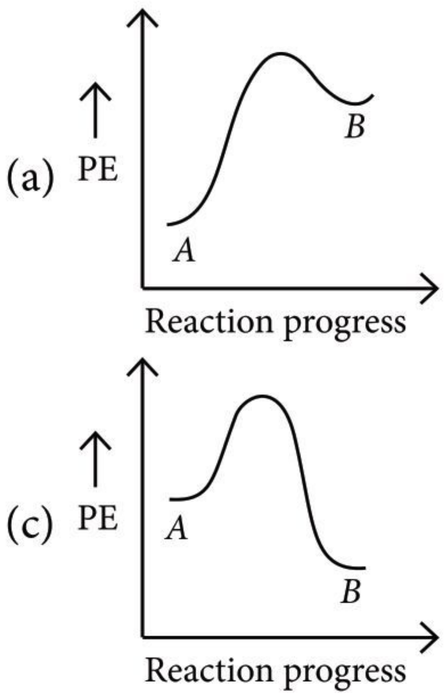
18. The pK_b of dimethylamine and pK_a of acetic acid are 3.27 and 4.77 respectivey at T(K). The correct option for the pH of dimethylammonium acetate solution is
(a) 6.25 (b) 8.50 (c) 5.50 (d) 7.75

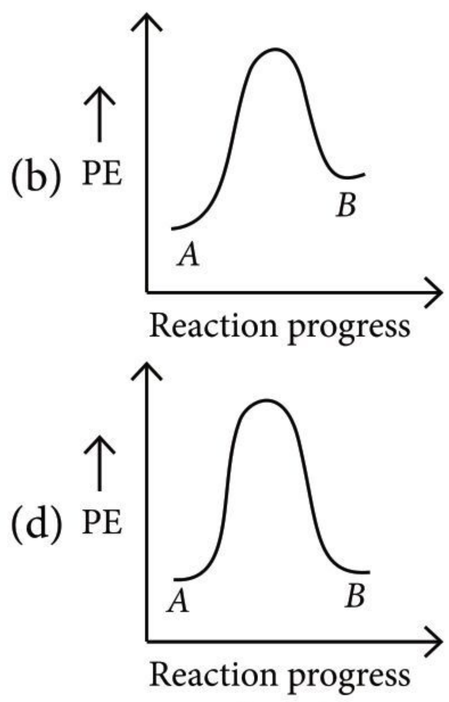
19. The following solutions were prepared by dissolving 10 g of glucose ($C_6H_{12}O_6$) in 250 mL of water (P_1). 10 g of urea (CH_4N_2O) in 250 mL of water (P_2) and 10 g of sucrose ($C_{12}H_{22}O_{11}$) in 250 mL of water (P_3). The right option for the decreasing order of osmotic pressure of these solutions is
(a) $P_3 > P_1 > P_2$ (b) $P_2 > P_1 > P_3$
(c) $P_1 > P_2 > P_3$ (d) $P_2 > P_3 > P_1$

20. The correct option for the number of body centred unit cells in all 14 types of Bravais lattice unit cells is
(a) 3 (b) 7 (c) 5 (d) 2

21. The maximum temperature that can be achieved in blast furnace is
(a) upto 5000 K (b) upto 1200 K
(c) upto 2200 K (d) upto 1900 K.

22. For a reaction $A \longrightarrow B$, enthalpy of reaction is –4.2 kJ mol^{-1} and enthalpy of activation is 9.6 kJ mol^{-1}. The correct potential energy profile for the reaction is shown in option

(a) 

(b) 

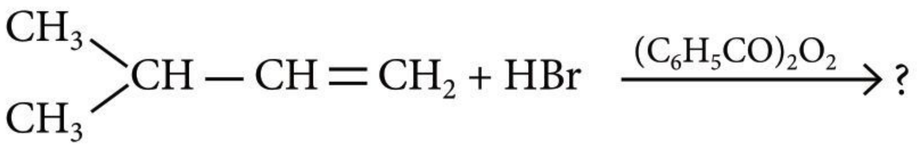
(c)

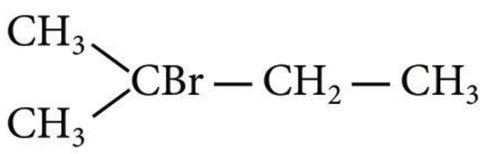
(d)

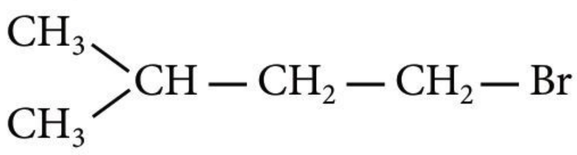
23. The compound which shows metamerism is

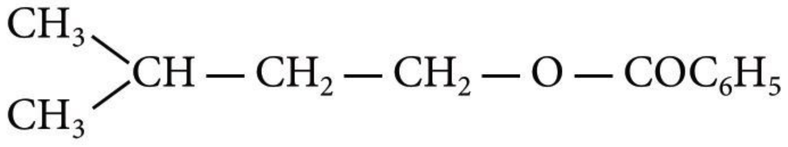
(a) $C_4H_{10}O$ (b) C_5H_{12} (c) C_3H_8O (d) C_3H_6O

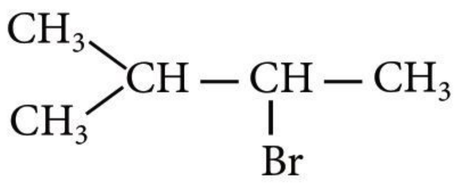
24. The major product of the following chemical reaction is



(a) 

(b) 

(c) 

(d) 

25. Which of the following reactions is the metal displacement reaction? Choose the right option.

(a) $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2\uparrow$

(b) $2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$

(c) $Cr_2O_3 + 2Al \xrightarrow{\Delta} Al_2O_3 + 2Cr$

(d) $Fe + 2HCl \longrightarrow FeCl_2 + H_2\uparrow$

26. Given below are two statements:

Statement I : Aspirin and Paracetamol belong to the class of narcotic analgesics.

Statement II : Morphine and Heroin are non-narcotic analgesics.

In the light of the above statements, choose the correct answer from the options given below.

(a) Statment I is incorrect but statement II is true.
(b) Both statement I and statement II are true.
(c) Both statement I and statement II are false.
(d) Statement I is correct but statement II is false.

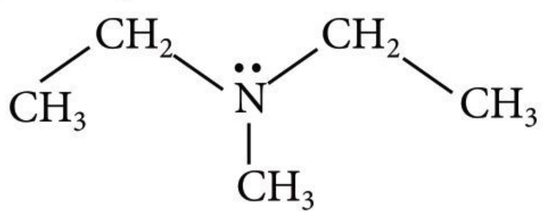
27. Ethylene diaminetetraacetate (EDTA) ion is

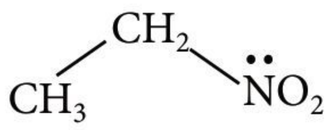
(a) tridentate ligand with three "N" donor atoms
(b) hexadentate ligand with four "O" and two "N" donor atoms
(c) unidentate ligand
(d) bidentate ligand with two "N" donor atoms.

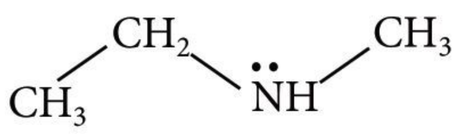
28. Which one of the following methods can be used to obtain highly pure metal which is liquid at room temperature?

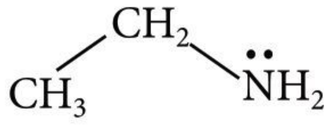
(a) Zone refining (b) Electrolysis
(c) Chromatography (d) Distillation

29. Identify the compound that will react with Hinsberg's reagent to give a solid which dissolves in alkali.

(a) 

(b) 

(c) 

(d) 

30. Among the following alkaline earth metal halides one which is covalent and soluble in organic solvents is

(a) beryllium chloride (b) calcium chloride
(c) strontium chloride (d) magnesium chloride

31. Dihedral angle of least stable conformer of ethane is

(a) 0° (b) 120° (c) 180° (d) 60°

32. An organic compound contains 78% (by wt.) carbon and remaining percentage of hydrogen. The right option for the empirical formula of this compound is [Atomic wt. of C is 12, H is 1]

(a) CH_4 (b) CH (c) CH_2 (d) CH_3

33. Noble gases are named because of their inertness towards reactivity. Identify an incorrect statement about them.

(a) Noble gases have large positive values of electron gain enthalpy.
(b) Noble gases are sparingly soluble in water.
(c) Noble gases have very high melting and boiling points.
(d) Noble gases have weak dispersion forces.

34. Which of the following polymers is prepared by addition polymerisation?

(a) Dacron (b) Teflon
(c) Nylon-6,6 (d) Novolac

35. Match List-I with List-II.

List I		List II	
(A)	PCl_5	(i)	Square pyramidal
(B)	SF_6	(ii)	Trigonal planar
(C)	BrF_5	(iii)	Octahedral
(D)	BF_3	(iv)	Trigonal bipyramidal

Choose the correct answer from the options given below.

(a) (A) – (iv), (B) – (iii), (C) – (ii), (D) – (i)
(b) (A) – (iv), (B) – (iii), (C) – (i), (D) – (ii)
(c) (A) – (ii), (B) – (iii), (C) – (iv), (D) – (i)
(d) (A) – (iii), (B) – (i), (C) – (iv), (D) – (ii)

SECTION - B

36. For irreversible expansion of an ideal gas under isothermal condition, the correct option is

(a) $\Delta U \neq 0, \Delta S_{total} = 0$ (b) $\Delta U = 0, \Delta S_{total} = 0$
(c) $\Delta U \neq 0, \Delta S_{total} \neq 0$ (d) $\Delta U = 0, \Delta S_{total} \neq 0$

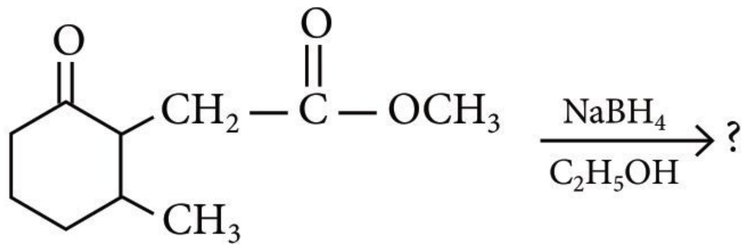
37. Match List-I with List-II.

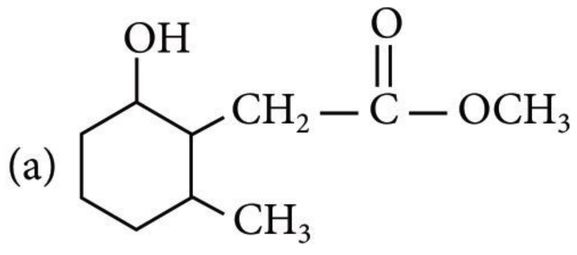
List I		List II	
(A)	$[Fe(CN)_6]^{3-}$	(i)	5.92 BM
(B)	$[Fe(H_2O)_6]^{3+}$	(ii)	0 BM
(C)	$[Fe(CN)_6]^{4-}$	(iii)	4.90 BM
(D)	$[Fe(H_2O)_6]^{2+}$	(iv)	1.73 BM

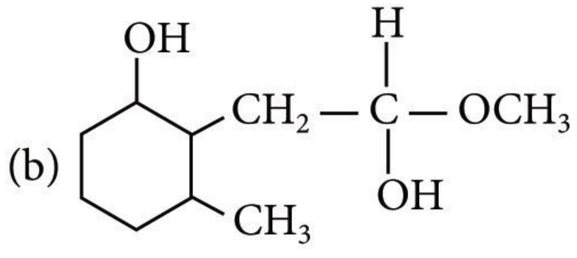
Choose the correct answer from the options given below.

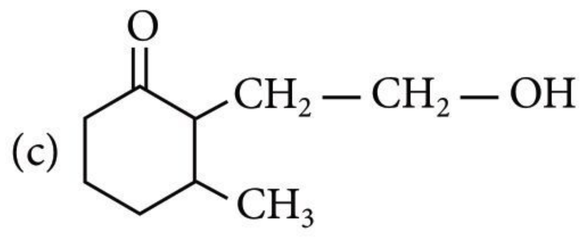
(a) (A) – (iv), (B) – (i), (C) – (ii), (D) – (iii)
(b) (A) – (iv), (B) – (ii), (C) – (i), (D) – (iii)
(c) (A) – (ii), (B) – (iv), (C) – (iii), (D) – (i)
(d) (A) – (i), (B) – (iii), (C) – (iv), (D) – (ii)

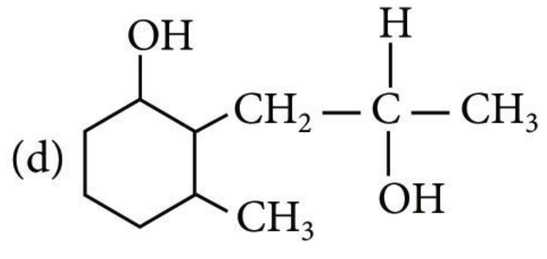
38. The product formed in the following chemical reaction is



(a)


(b)


(c)


(d)


39. In which one of the following arrangements the given sequence is not strictly according to the properties indicated against it?

(a) $CO_2 < SiO_2 < SnO_2 < PbO_2$: Increasing oxidizing power
(b) $HF < HCl < HBr < HI$: Increasing acidic strength
(c) $H_2O < H_2S < H_2Se < H_2Te$: Increasing p*Ka* values
(d) $NH_3 < PH_3 < AsH_3 < SbH_3$: Increasing acidic character

40. $CH_3CH_2COO^-Na^+ \xrightarrow[\text{Heat}]{NaOH, + ?} CH_3CH_3 + Na_2CO_3$

Consider the above reaction and identify the missing reagent /chemical.

(a) DIBAL-H (b) B_2H_6
(c) Red phosphorus (d) CaO

41. Which of the following molecules is non-polar in nature?

(a) NO_2 (b) $POCl_3$ (c) CH_2O (d) $SbCl_5$

42. Match List-I with List-II.

List I		List II	
(A)	$2SO_{2(g)} + O_{2(g)} \longrightarrow 2SO_{3(g)}$	(i)	Acid rain
(B)	$HOCl_{(g)} \xrightarrow{h\upsilon} \dot{O}H + \dot{C}l$	(ii)	Smog
(C)	$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$	(iii)	Ozone depletion
(D)	$NO_{2(g)} \xrightarrow{h\upsilon} NO_{(g)} + O_{(g)}$	(iv)	Tropospheric pollution

Choose the correct answer from the options given below.

(a) (A) – (iii), (B) – (ii), (C) – (iv), (D) – (i)
(b) (A) – (i), (B) – (ii), (C) – (iii), (D) – (iv)
(c) (A) – (ii), (B) – (iii), (C) – (iv), (D) – (i)
(d) (A) – (iv), (B) – (iii), (C) – (i), (D) – (ii)

43. The molar conductivity of 0.007 M acetic acid is 20 S cm^2 mol^{-1}. What is the dissociation constant of acetic acid? Choose the correct option.

$$\begin{bmatrix} \Lambda^\circ_{H^+} = 350\ S\ cm^2\ mol^{-1} \\ \Lambda^\circ_{CH_3COO^-} = 50\ S\ cm^2\ mol^{-1} \end{bmatrix}$$

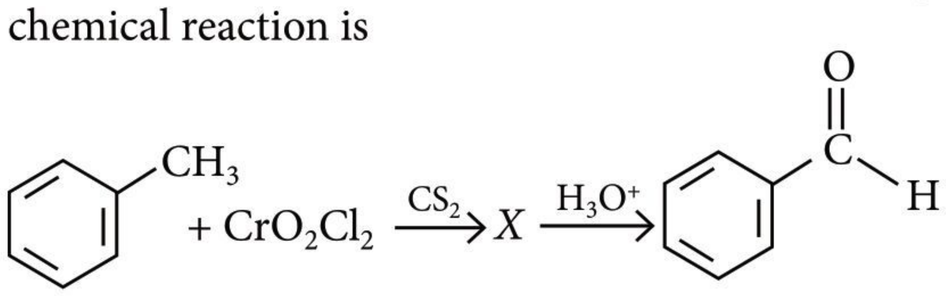
(a) 2.50×10^{-5} mol L^{-1} (b) 1.75×10^{-4} mol L^{-1}
(c) 2.50×10^{-4} mol L^{-1} (d) 1.75×10^{-5} mol L^{-1}

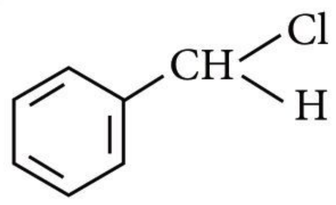
44. Choose the correct option for the total pressure (in atm) in a mixture of 4 g O_2 and 2 g H_2 confined in a total volume of one litre at 0°C is
[Given R = 0.082 L atm mol^{-1} K^{-1}, T = 273 K]
(a) 26.02 (b) 2.518 (c) 2.602 (d) 25.18

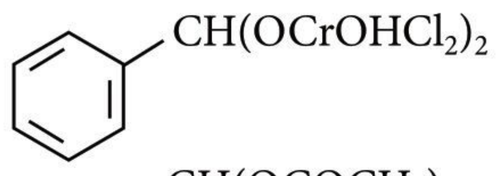
45. The correct option for the value of vapour pressure of a solution at 45°C with benzene to octane in molar ratio 3 : 2 is
[At 45°C vapour pressure of benzene is 280 mm Hg and that of octane is 420 mm Hg. Assume ideal gas]
(a) 350 mm of Hg (b) 160 mm of Hg
(c) 168 mm of Hg (d) 336 mm of Hg

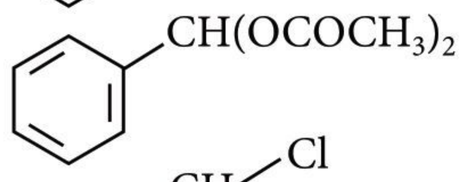
46. From the following pairs of ions which one is not an iso-electronic pair?
(a) Fe^{2+}, Mn^{2+} (b) O^{2-}, F^-
(c) Na^+, Mg^{2+} (d) Mn^{2+}, Fe^{3+}

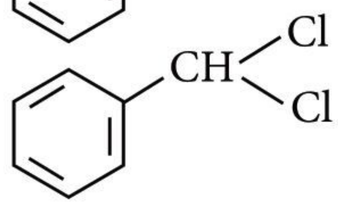
47. The intermediate compound X in the following chemical reaction is



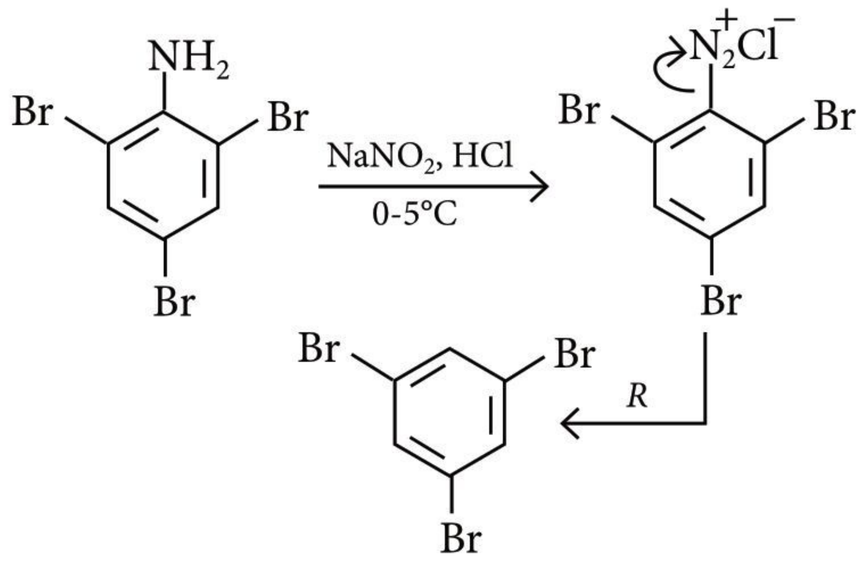
(a) 

(b) 

(c) 

(d) 

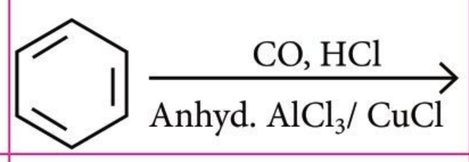
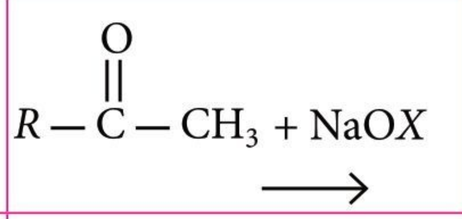
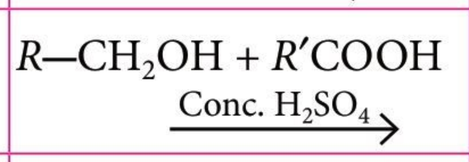
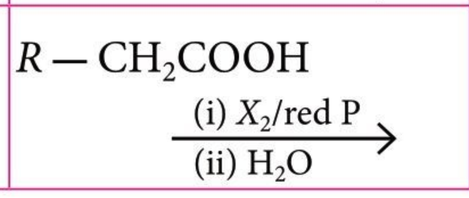
48. The reagent in 'R' in the given sequence of chemical reaction is



(a) $CuCN/KCN$ (b) H_2O
(c) CH_3CH_2OH (d) HI

49. The slope of Arrhenius plot $\left(\ln k \; vs \frac{1}{T}\right)$ of first order reaction is -5×10^3 K. The value of E_a of the reaction is [Given : R = 8.314 J K^{-1} mol^{-1})
(a) −83 kJ mol^{-1} (b) 41.5 kJ mol^{-1}
(c) 83.0 kJ mol^{-1} (d) 166 kJ mol^{-1}

50. Match List-I with List-II.

List I		List II	
(A)		(i)	Hell Volhard Zelinsky reaction
(B)		(ii)	Gattermann-Koch reaction
(C)		(iii)	Haloform reaction
(D)		(iv)	Esterification

Choose the correct answer from the options given below.
(a) (A) – (ii), (B) – (iii), (C) – (iv), (D) – (i)
(b) (A) – (iv), (B) – (i), (C) – (ii), (D) – (iii)
(c) (A) – (iii), (B) – (ii), (C) – (i), (D) – (iv)
(d) (A) – (i), (B) – (iv), (C) – (iii), (D) – (ii)

SOLUTIONS

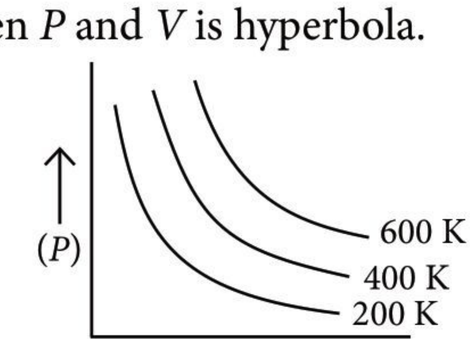
1. (a) : Number of atoms in hexagonal unit cell = N = 6
Number of octahedral void = N = 6
Number of tetrahedral void = $2N$ = 12

2. (d) : The atomic and ionic radii of Zr and Hf are almost identical due to poor shielding effect of 4*f*-electrons, which lead to the lanthanoid contraction.

3. (a) : According to Boyle's law,

$$P \propto \frac{1}{V} \text{ (at constant } T\text{)}$$

Graph between P and V is hyperbola.

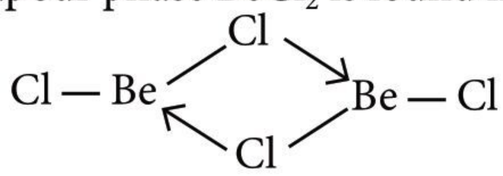


4. (d) : As starch solution is a colloidal solution hence it exhibits Tyndall effect. NaCl, urea and glucose form true solution.

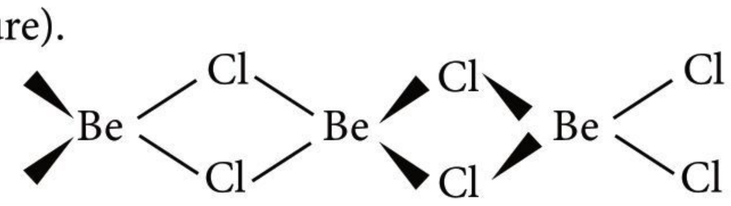
5. (c) : $C_P = C_V + nR$

For one mole of ideal gas, $C_P = C_V + R$ or $C_P - C_V = R$

6. (b) : In vapour phase $BeCl_2$ is found in dimer form.



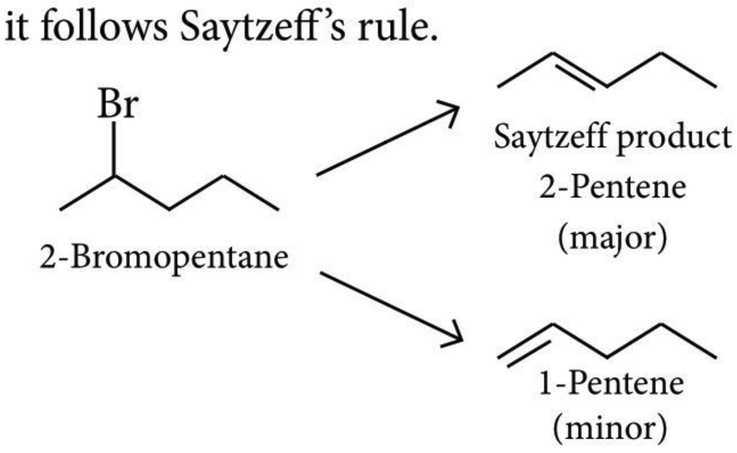
While in solid state it is found as a polymer (chain structure).



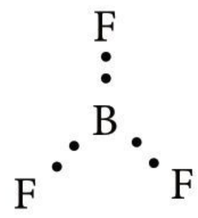
7. (b) : Tritium is beta particle emitting radioactive isotope of hydrogen.

$$\underset{\text{Tritium}}{{}^{3}_{1}H} \longrightarrow {}^{3}_{2}He + \underset{\beta\text{-particle}}{{}^{0}_{-1}e} + \upsilon$$

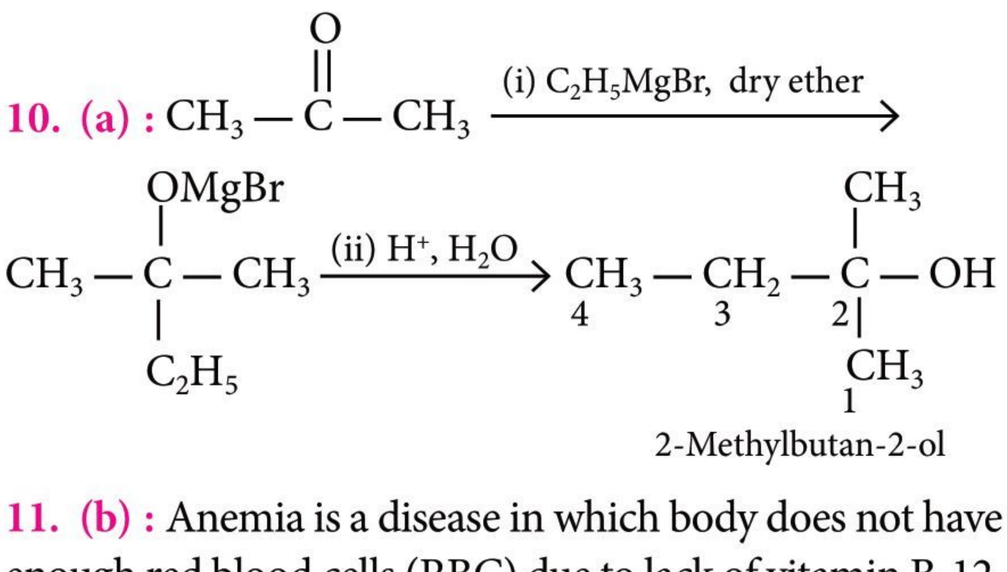
8. (b) : It is an example of β-elimination, as the major product is 2-pentene (more substituted) not 1-pentene, hence it follows Saytzeff's rule.



9. (d) : BF_3 is a sp^2-hybridised planar molecule. It forms 3σ-bonds with 3F-atoms hence has six electrons around it.



10. (a) :



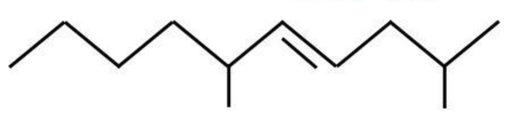
11. (b) : Anemia is a disease in which body does not have enough red blood cells (RBC) due to lack of vitamin B-12. This vitamin is needed to make red blood cells.

12. (c) : $\Lambda^{\infty}_{CH_3COOH} = \Lambda^{\circ}_{CH_3COONa} + \Lambda^{\circ}_{HCl} - \Lambda^{\circ}_{NaCl}$

$= 91.0 + 426.16 - 126.45 = 390.71\ S\ cm^2\ mol^{-1}$

13. (c) **14. (b)**

15. (b) :



2,6-Dimethyl-dec-4-ene

16. (c) : The correct order of bond enthalpy is

$CH_3 — F > CH_3 — Cl > CH_3 — Br > CH_3 — I$

17. (b) : $\upsilon = \frac{c}{\lambda}$

$$\lambda = \frac{c}{\upsilon} = \frac{3\times10^8\ m\ s^{-1}}{1368\times10^3\ s^{-1}} = 219.3\ m$$

18. (d) : For a salt of weak acid and weak base

$$pH = 7 + \frac{1}{2}(pK_a - pK_b)$$

Given, $pK_a = 4.77$, $pK_b = 3.27$

$$pH = 7 + \frac{1}{2}(4.77 - 3.27) = 7.75$$

19. (b) : Osmotic pressure (π) = CRT

$\therefore \quad \pi \propto C$

For glucose solution, $C_1 = \frac{10}{180} \times \frac{1000}{250} = 0.22\ M$

For urea solution, $C_2 = \frac{10}{60} \times \frac{1000}{250} = 0.66\ M$

For sucrose solution, $C_3 = \frac{10}{342} \times \frac{1000}{250} = 0.117\ M$

Hence, order of osmotic pressure is $P_2 > P_1 > P_3$.

20. (a) : Out of 14 types of Bravais lattice, three body centred units cells are there which are :

orthorhombic, tetragonal and cubic

21. (c) : It can withstand upto approximately 2000°C or 2200 K.

22. (c) : As enthalpy of reaction is negative, hence it is an exothermic reaction.

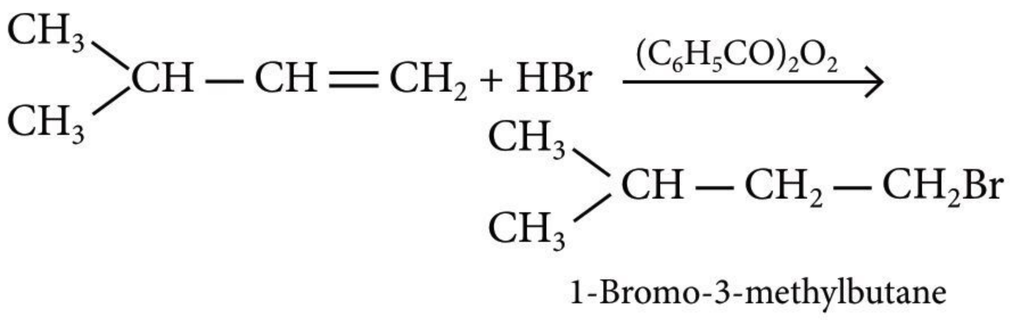
23. (a) : Metamerism occurs when the compound has different number of carbon atoms on either side of the functional group.

Metamers of $C_4H_{10}O$:

$CH_3 — O — CH_2CH_2CH_3$
Methylpropyl ether

$CH_3CH_2 — O — CH_2CH_3$
Diethyl ether

24. (b) : In presence of peroxide, anti-Markownikoff addition reaction takes place.



1-Bromo-3-methylbutane

25. (c) : When a metal from the electrochemical series is mixed with the ions of a metal lower down in the electrochemical series, then more active metal displaces the less active one, this is known as metal displacement. Hence, the correct reaction is

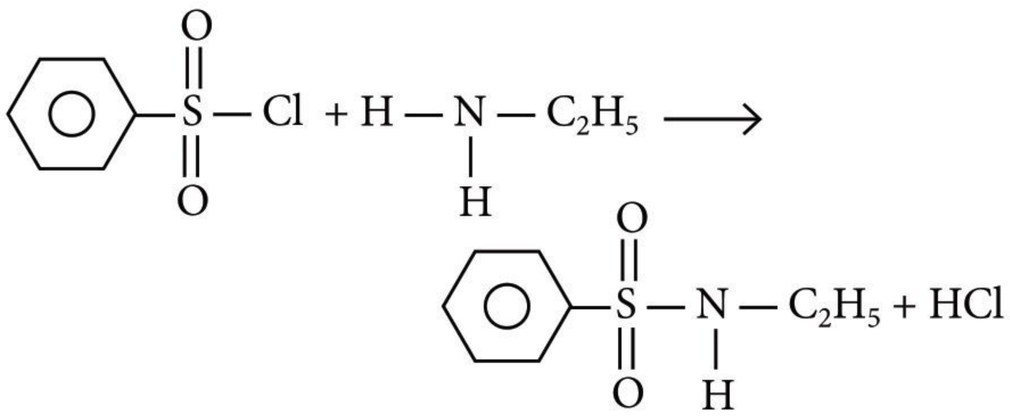
$$Cr_2O_3 + 2Al \xrightarrow{\Delta} Al_2O_3 + 2Cr$$

26. (c) : Aspirin and paracetamol belong to the class of non-narcotic analgesics, while morphine and many of its homologues like heroin belong to the class of narcotic analgesics.

27. (b) : Ethylenediaminetetraacetate ion ($EDTA^{4-}$) is an important hexadentate ligand. It can bind through two nitrogen and four oxygen atoms to a central metal ion.

28. (d)

29. (d) : Benzene sulphonyl chloride ($C_6H_5SO_2Cl$), which is also known as Hinsberg's reagent, reacts with primary amines to form sulphonamides. The hydrogen attached to nitrogen in sulphonamide is strongly acidic due to the presence of strong electron withdrawing sulphonyl group. Hence, it is soluble in alkali.



N-Ethylbenzenesulphonamide
(Soluble in alkali)

30. (a) : Except for beryllium halides, all other halides of alkaline earth metals are ionic in nature. Beryllium halides are essentially covalent and soluble in organic solvents.

31. (a) : Dihedral angle of least stable conformer of ethane is 0°. Magnitude of torsional strain depends upon the angle of rotation about C — C bond. This angle is also called dihedral angle or torsional angle. Of all the conformations of ethane, the staggered form has the least torsional strain and the eclipsed form, the maximum torsional strain.

32. (d) : Given percentage of carbon - 78% and hence, percentage of hydrogen - 22%.

Element	%	Relative number of atoms	Simplest ratio
Carbon	78	$\frac{78}{12} = 6.5$	$\frac{6.5}{6.5} = 1$
Hydrogen	22	$\frac{22}{1} = 22$	$\frac{22}{6.5} = 3.3 \approx 3$

$\therefore$ Empirical formula = CH_3

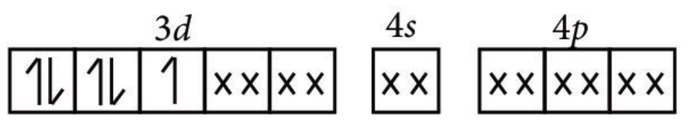
33. (c) : Noble gases have very low melting and boiling points because the only type of interatomic interaction in these elements is weak dispersion forces.

34. (b) : Among the given polymers teflon polymer is prepared by addition polymerisation.

35. (b) : PCl_5 : Trigonal bipyramidal
SF_6 : Octahedral
BrF_5 : Square pyramidal
BF_3 : Trigonal planar

36. (d) : For reversible and irreversible expansion for an ideal gas under isothermal condition, $\Delta U = 0$, but ΔS_{total} *i.e.*, $\Delta S_{sys} + \Delta S_{Surr}$ is not zero for irreversible process.

37. (a) : $[Fe(CN)_6]^{3-}$:



Spin only magnetic moment = $\sqrt{n(n+2)}$
where n = number of unpaired electrons.
Hence, $n = 1$.

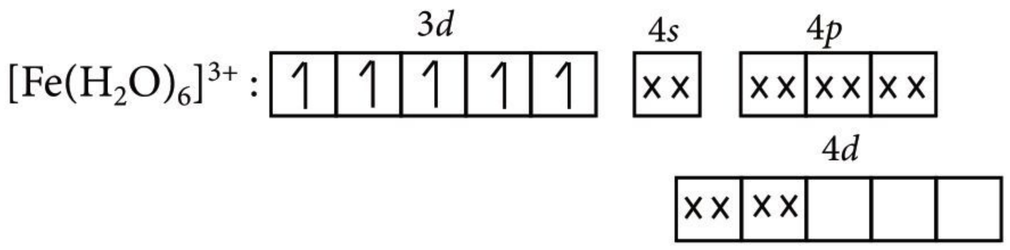
$$\mu = \sqrt{1(1+2)} = \sqrt{3} = 1.73 \text{ B.M.}$$

COMIC CAPSULE

What is the chemical formula for the molecules in chocolate?

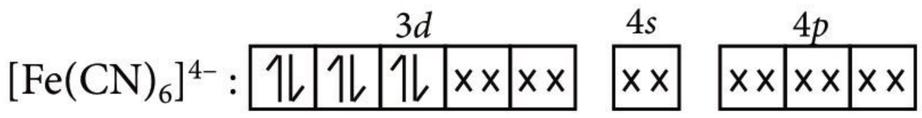
A : Carbon-Holmium-Cobalt-Lanthanum-Tellurium
CHoCoLaTe

$[Fe(H_2O)_6]^{3+}$:



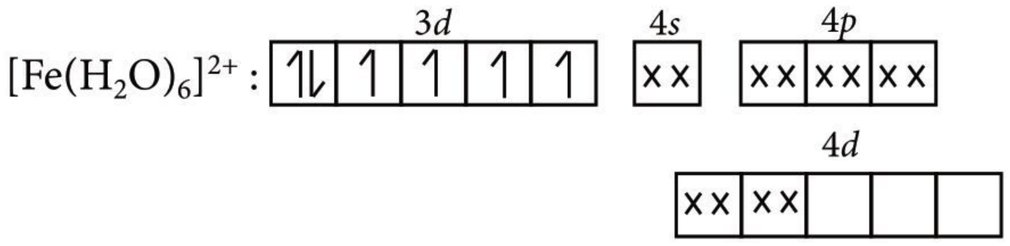
$n = 5,\ \mu = \sqrt{5(5+2)} = \sqrt{35} = 5.92$ B.M.

$[Fe(CN)_6]^{4-}$:



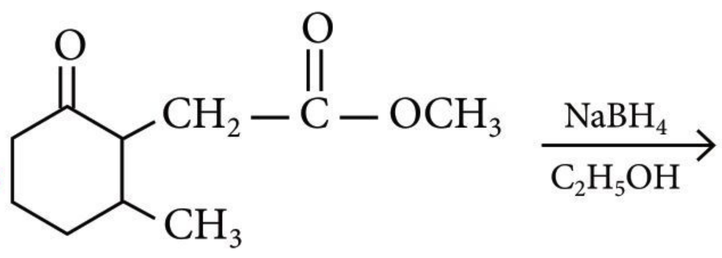
$n = 0,\ \mu = \sqrt{0} = 0$ B.M.

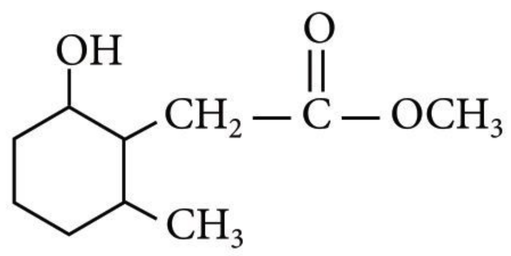
$[Fe(H_2O)_6]^{2+}$:



$n = 4,\ \mu = \sqrt{4(4+2)} = \sqrt{24} = 4.90$ B.M.

38. (a) :





$NaBH_4$ is less powerful reducing agent than $LiAlH_4$. It is only powerful enough to reduce aldehydes, ketones and acid chlorides to alcohols. Esters, amides, acids and nitrites are not reduced.

39. (c) :

	pK_a
H_2O	14
H_2S	7
H_2Se	3.87
H_2Te	2.6

40. (d) : $CH_3CH_2COO^-Na^+ + NaOH \xrightarrow[\text{heat}]{CaO} CH_3CH_3 + Na_2CO_3$

41. (d) : Among the given molecules, $SbCl_5$ is non-polar in nature.

42. (d) : Photochemical smog : $NO_{2(g)} \xrightarrow{h\upsilon} NO_{(g)} + O_{(g)}$

Ozone depletion : $HOCl_{(g)} \xrightarrow{h\upsilon} \dot{O}H + \dot{C}l$

Acid rain : $CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$

Tropospheric pollution : $2SO_{2(g)} + O_{2(g)} \longrightarrow 2SO_{3(g)}$

43. (d) : $\Lambda^\circ_{m(CH_3COOH)} = \lambda^\circ_{H^+} + \lambda^\circ_{CH_3COO^-}$

$= 350 + 50 = 400\ S\ cm^2\ mol^{-1}$

Degree of dissociation, $\alpha = \dfrac{\Lambda^c_m}{\Lambda^\circ_m} = \dfrac{20}{400} = 0.05$

So, dissociation constant,

$K_a = c\alpha^2$ (for weak electrolytes)

$= 0.007 \times (0.05)^2 = 1.75 \times 10^{-5}\ mol\ L^{-1}$

44. (d) : Applying $PV = \dfrac{w}{M}RT$

$P_{O_2} = \dfrac{4}{32} \times \dfrac{0.0821 \times 273}{1} = 2.80$ atm

$P_{H_2} = \dfrac{2}{2} \times \dfrac{0.0821 \times 273}{1} = 22.4$ atm

Now, according to Dalton's law,

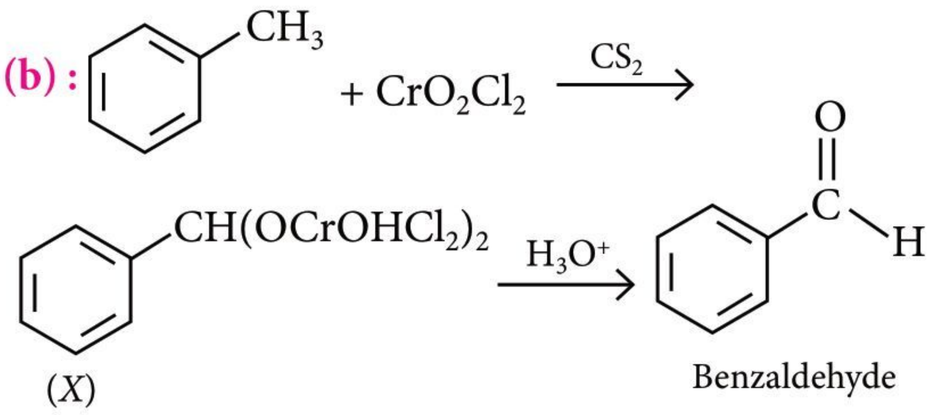
$P_{total} = P_{O_2} + P_{H_2} = 2.80 + 22.4 = 25.2$ atm

45. (d) : $P_{total} = p_{benzene}\, x_{benzene} + p_{octane}\, x_{octane}$

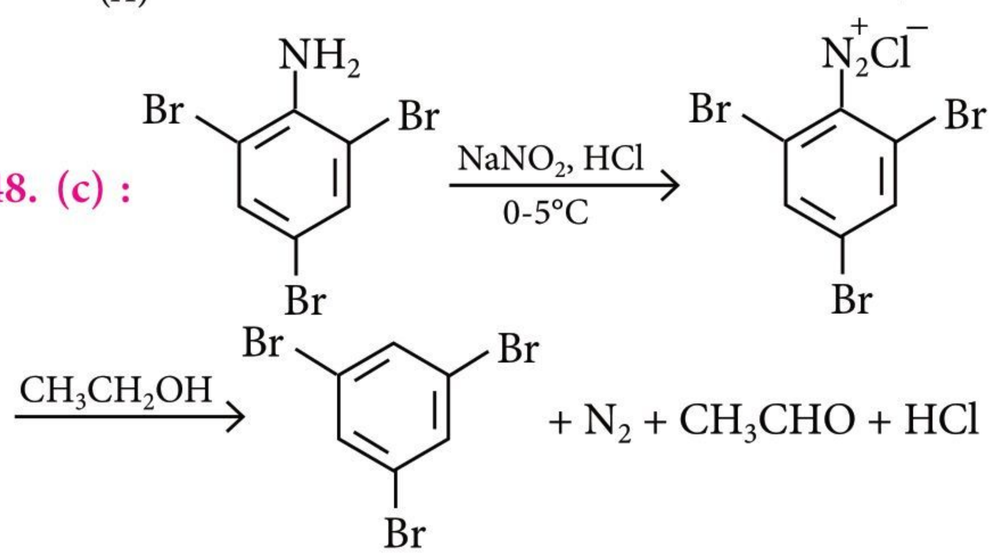
$= 280 \times \dfrac{3}{5} + 420 \times \dfrac{2}{5} = 168 + 168 = 336$ mm of Hg

46. (a) : Among the given pairs of ions, Fe^{2+} and Mn^{2+} is not an iso-electronic pair.

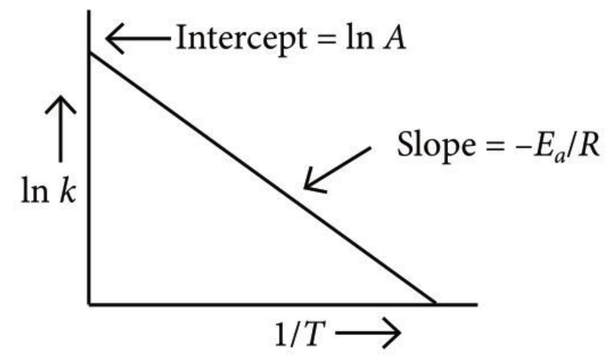
47. (b) :



48. (c) :



49. (b) : $\ln K = -\dfrac{E_a}{RT} + \ln A$



$-\dfrac{E_a}{R} = -5 \times 10^3 = -5000$

$\Rightarrow\ E_a = 5000 \times 8.314 = 41570\ J\ mol^{-1} = 41.57\ kJ\ mol^{-1}$

50. (a) : Hell — Volhard — Zelinsky reaction:

$$R-CH_2COOH \xrightarrow[(ii)\ H_2O]{(i)\ X_2/\text{red phosphorus}} R-\underset{\underset{X}{|}}{CH}-COOH \quad (X = Cl, Br)$$

Haloform reaction:

$$R-\overset{\overset{O}{\|}}{C}-CH_3 \xrightarrow{NaOX} R-\overset{\overset{O}{\|}}{C}-ONa + CHX_3 \quad (X = Cl, Br, I)$$

Esterification:

$$R-CH_2OH + R'COOH \xrightarrow{\text{Conc. } H_2SO_4} R'COOCH_2R + H_2O$$

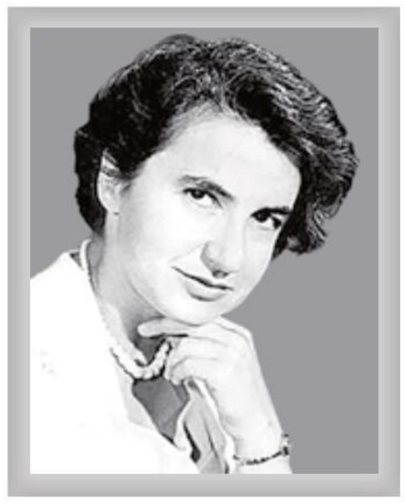
Gatterman — Koch reaction:

Scientist of the Month

Rosalind Elsie Franklin

Early Life and Education

- Franklin was born on 25 July 1920 in London, into an affluent and influential British Jewish family. From early childhood, Franklin showed exceptional scholastic abilities. With six distinctions, she passed her matriculation in 1938, winning a scholarship for university. Franklin went to Newnham College, Cambridge in 1938 and studied chemistry within the Natural Sciences Tripos. Franklin was awarded a research fellowship at Newnham College, with which she joined the physical chemistry laboratory of the University of Cambridge to work under Ronald George Wreyford Norrish, who later won the Nobel Prize in Chemistry.



Rosalind Elsie Franklin
(25 July 1920 - 16 April 1958)

Contributions

- Rosalind Franklin's first important contributions to the model popularised by Crick and Watson was her lecture at the seminar in November 1951, where she presented to those present, among them Watson, the two forms of the molecule, type A and type B, her position being that the phosphate units are located in the external part of the molecule. She discovered that the DNA sample could exist in two forms : at a relative humidity higher than 75%, the DNA fibre became long and thin; when it was drier, it became short and fat.
- She collaborated on studies showing that the RNA in tobacco mosaic virus was embedded in its protein rather than in its central cavity and that this RNA is single strand helix, rather than double helix found in DNA.
- The other contribution included an X-ray photograph of B-DNA (called Photo 51) taken by Franklin's student Gosling that was briefly shown to Watson by Wilkins in January 1953.

Awards and Honors

- 1982, Iota Sigma Pi designated Franklin a National Honorary Member.
- 1984, St Paul's Girls School established the Rosalind Franklin Technology Centre.
- 1992, English Heritage placed a blue plaque commemorating Franklin on the building in Drayton Gardens, London, where she lived until her death.
- 1997, Birkbeck, University of London School of Crystallography opened the Rosalind Franklin Laboratory.
- 1997, a newly discovered asteroid was named 9241 Rosfranklin.
- 1998, National Portrait Gallery in London added Rosalind Franklin's portrait next to those of Francis Crick, James Watson and Maurice Wilkins.
- 2000, King's College London opened the Franklin–Wilkins Building in honour of Franklin's and Wilkins's work at the college.
- 2001, the American National Cancer Institute established the Rosalind E. Franklin Award for women in cancer research.
- 2003, the Royal Society established the Rosalind Franklin Award (officially the Royal Society Rosalind Franklin Award and Lecture) for an outstanding contribution to any area of natural science, engineering or technology.
- 2005, the DNA sculpture (donated by James Watson) outside Clare College, Cambridge's Memorial Court incorporates the words "The double helix model was supported by the work of Rosalind Franklin and Maurice Wilkins.
- 2008, Columbia University awarded an honorary Louisa Gross Horwitz Prize to Franklin, "for her seminal contributions to the discovery of the structure of DNA".
- 2012, the bioinformatics education software platform Rosalind was named in honour of Franklin.
- 2014, the Rosalind Franklin University of Medicine and Science unveiled a bronze statue of Franklin, created by Julie Rotblatt-Amrany, near its front entrance.
- 2014, the Rosalind Franklin STEM Elementary was opened in Pasco, Washington, the first science, technology, engineering, and math (STEM) elementary school in the district.
- 2015, a high performance computing and cloud facility in London was named Rosalind.
- 2016, the Rosalind Franklin Prize and Tech Day was held on 23 February in London, organised by University College London, i-sense, UCL Enterprise, the London Centre for Nanotechnology and the UCL Athena Swan Charter.

SOLVED PAPER

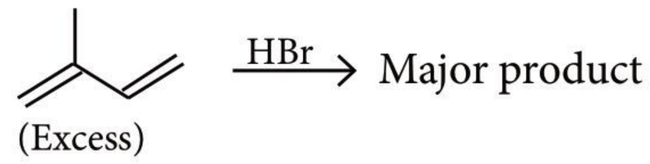
Held on
26th August, Morning Shift

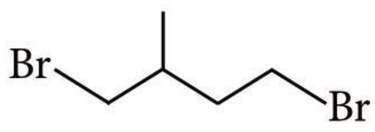
JEE MAIN 2021

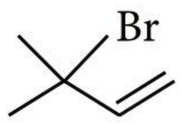
SECTION - A (MULTIPLE CHOICE QUESTIONS)

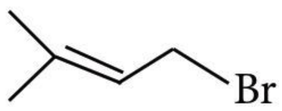
1. The incorrect statement is
(a) F_2 is a stronger oxidising agent than Cl_2 in aqueous solution
(b) on hydrolysis ClF forms HOCl and HF
(c) Cl_2 is more reactive than ClF
(d) F_2 is more reactive than ClF.

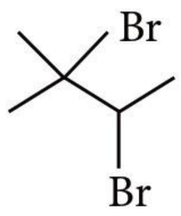
2. The major product formed in the following reaction is



(a) 

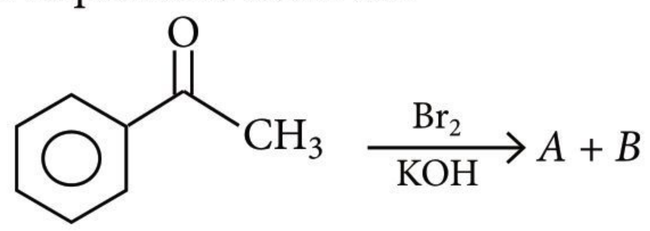
(b) 

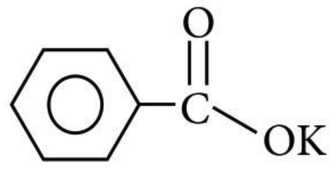
(c) 

(d) 

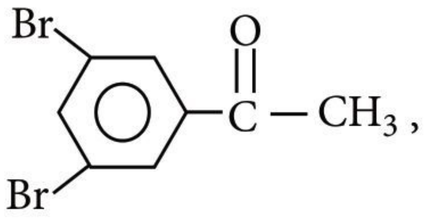
3. Given below are two statements:
Statement-I : Frenkel defects are vacancy as well as interstitial defects.
Statement-II : Frenkel defect leads to colour in ionic solids due to presence of F-centres.
Choose the most appropriate answer for the statements from the options given below:
(a) Statement-I is false but statement-II is true.
(b) Both statement I and statement-II are false.
(c) Statement-I is true but statement-II is false.
(d) Both statement I and statement-II are true.

4. The major products formed in the following reaction sequence *A* and *B* are

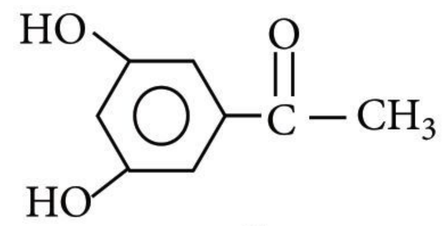


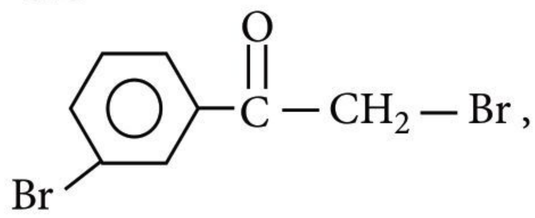
(a) *A* = 

, *B* = $CHBr_3$

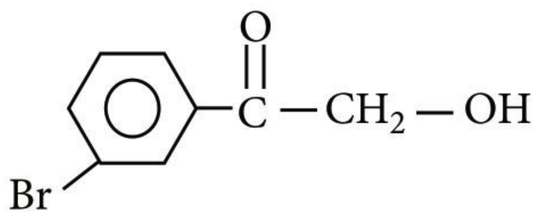
(b) *A* = 

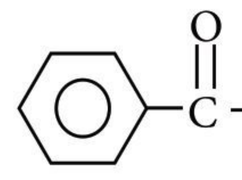
,

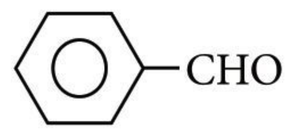
B = 

(c) *A* = 

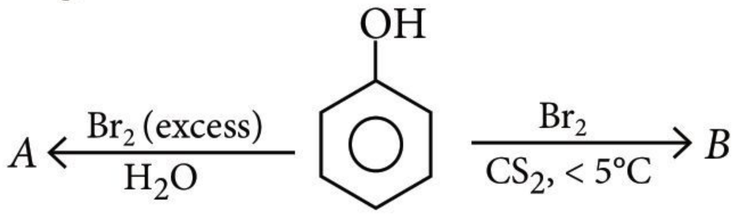
,

B = 

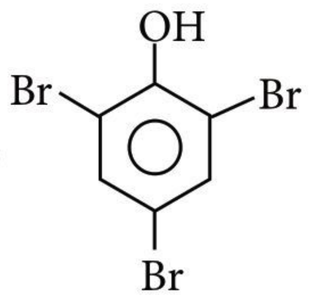
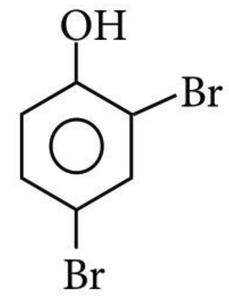
(d) *A* = 

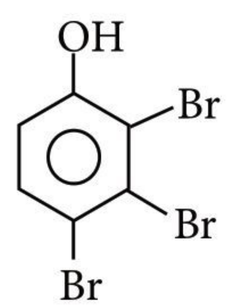
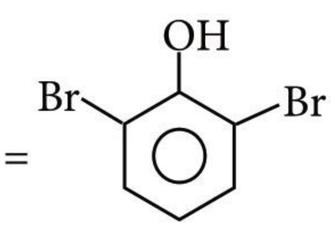
, *B* = 

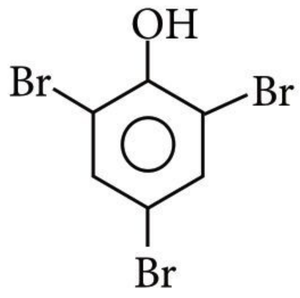
5. The correct option for the products *A* and *B* of the following reactions are



(a) $A =$  , $B =$ 

(b) $A =$  , $B =$ 

(c) $A =$  , $B =$ 

(d) $A =$  , $B =$ 

6. Given below are two statements:
Statement-I : The limiting molar conductivity of KCl (strong electrolyte) is higher compared to that of CH_3COOH (weak electrolyte).
Statement-II : Molar conductivity decreases with decrease in concentration of electrolyte.
In the light of the above statements, choose the most appropriate answer from the options given below:
(a) Statement-I is false but statement-II is true.
(b) Both statement I and statement-II are true.
(c) Statement-I is true but statement-II is false.
(d) Both statement I and statement-II are false.

7. Which one of the following methods is most suitable for preparing deionized water?
(a) Synthetic resin method
(b) Calgon's method
(c) Clark's method (d) Permutit method

8. Given below are two statements:
Statement-I : According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in positive charges on the nucleus as there is no strong hold on the electron by the nucleus.
Statement-II : According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in principal quantum number.
In the light of the above statements, choose the most appropriate answer from the options given below:
(a) Statement-I is false but statement-II is true.
(b) Statement-I is true but statement-II is false.
(c) Both statement I and statement-II are false.
(d) Both statement I and statement-II are true.

9. Excess of isobutane on reaction with Br_2 in presence of light at 125°C gives which one of the following, as the major product?

(a) $CH_3 - \underset{|}{CH} - CH_2Br$

(b) $CH_3 - \underset{\underset{CH_3}{|}}{\overset{CH_2Br}{|}}{CH} - CH_2Br$

(c) $CH_3 - \underset{\underset{CH_3}{|}}{\overset{Br}{|}}{C} - CH_2 - Br$

(d) $CH_3 - \underset{\underset{CH_3}{|}}{\overset{CH_3}{|}}{C} - Br$

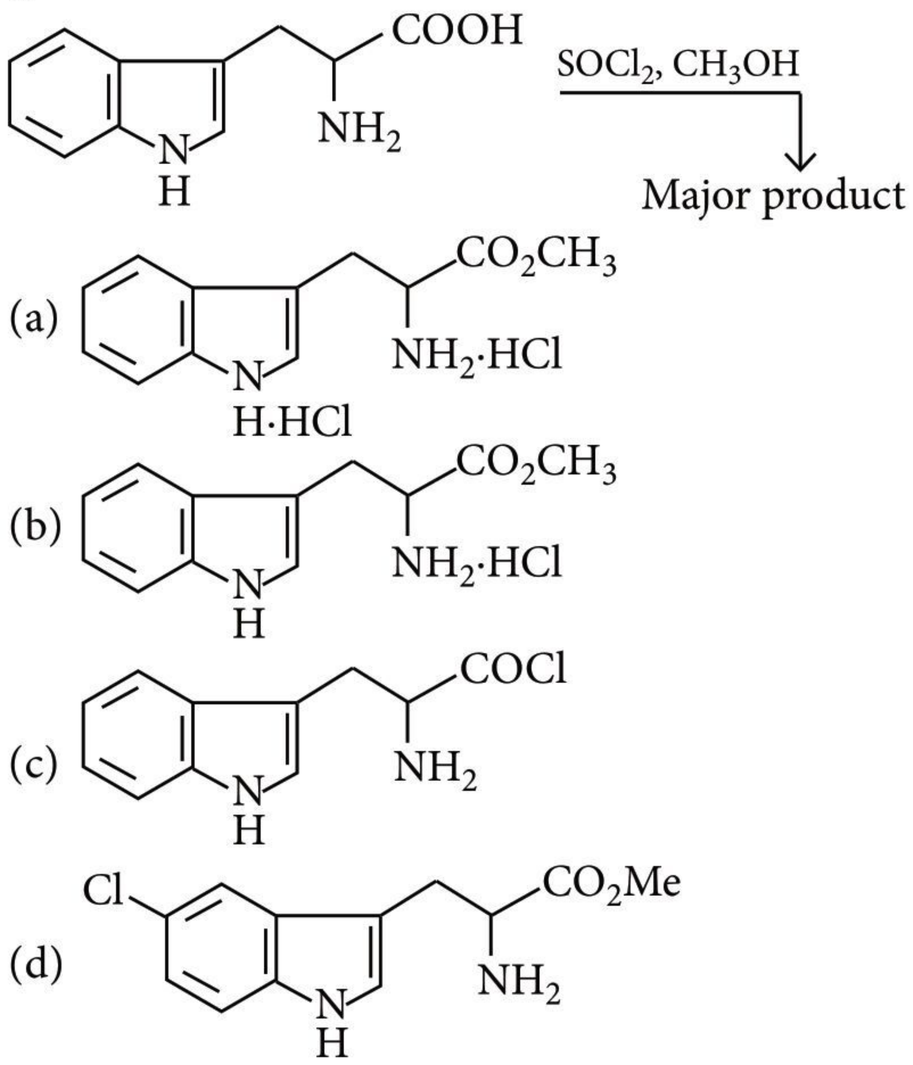
10. Which one of the following when dissolved in water gives coloured solution in nitrogen atmosphere?
(a) Cu_2Cl_2 (b) $ZnCl_2$
(c) $CuCl_2$ (d) AgCl

11. Which one of the following is correct for the adsorption of a gas at a given temperature on a solid surface?
(a) $\Delta H > 0, \Delta S > 0$ (b) $\Delta H < 0, \Delta S > 0$
(c) $\Delta H > 0, \Delta S < 0$ (d) $\Delta H < 0, \Delta S < 0$

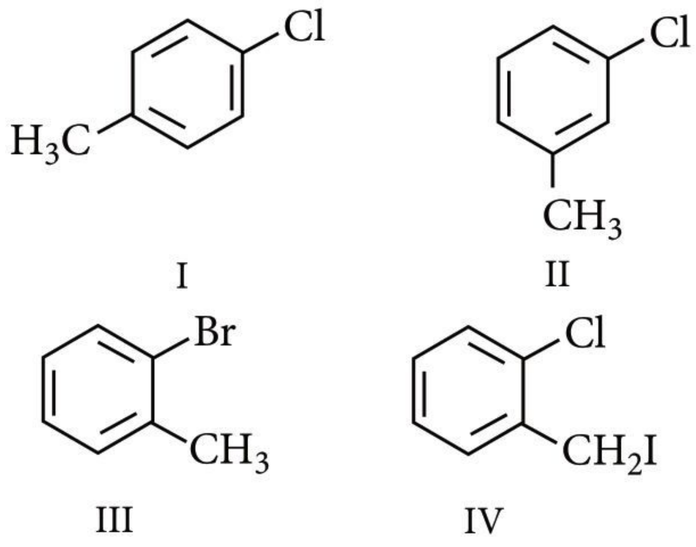
12. The conversion of hydroxyapatite occurs due to presence of F^- ions in water. The correct formula of hydroxyapatite is
(a) $[Ca_3(PO_4)_2 \cdot CaF_2]$ (b) $[3Ca_3(PO_4)_2 \cdot Ca(OH)_2]$
(c) $[3Ca_3(PO_4)_2 \cdot CaF_2]$ (d) $[3Ca(OH)_2 \cdot CaF_2]$

13. Given below are two statements:
Statement-I : In the titration between strong acid and weak base methyl orange is suitable as an indicator.
Statement-II : For titration of acetic acid with NaOH phenolphthalein is not a suitable indicator.
In the light of the above statements, choose the most appropriate answer from the options given below:
(a) Statement-I is false but statement-II is true.
(b) Both statement I and statement-II are true.
(c) Both statement I and statement-II are false.
(d) Statement-I is true but statement-II is false.

14. The major product formed in the following reaction is



15. Among the following compounds I - IV, which one forms a yellow precipitate on reacting sequentially with (i) NaOH, (ii) dil. HNO_3, (iii) $AgNO_3$?



(a) III (b) II (c) I (d) IV

16. What are the products formed in sequence when excess of CO_2 is passed in slaked lime?

(a) CaO, $CaCO_3$ (b) $Ca(HCO_3)_2$, $CaCO_3$
(c) $CaCO_3$, $Ca(HCO_3)_2$ (d) CaO, $Ca(HCO_3)_2$

17. The polymer formed on heating Novolac with formaldehyde is

(a) polyester (b) bakelite
(c) nylon 6,6 (d) melamine.

18. Given below are two statements:

Statement-I : The choice of reducing agents for metals extraction can be made by using Ellingham diagram, a plot of ΔG *vs* temperature.

Statement-II : The value of ΔS increases from left to right in Ellingham diagram.

In the light of the above statements, choose the most appropriate answer from the options given below:

(a) Statement-I is false but statement-II is true.
(b) Both statement I and statement-II are true.
(c) Statement-I is true but statement-II is false.
(d) Both statement I and statement-II are false.

19. Which one of the following complexes is violet in colour?

(a) $Fe_4[Fe(CN)_6]_3 \cdot H_2O$ (b) $[Fe(CN)_5NOS]^{4-}$
(c) $[Fe(SCN)_6]^{4-}$ (d) $[Fe(CN)_6]^{4-}$

20. The correct sequential addition of reagents in the preparation of 3-nitrobenzoic acid from benzene is

(a) $Br_2/AlBr_3$, HNO_3/H_2SO_4, Mg/ether, CO_2, H_3O^+
(b) $Br_2/AlBr_3$, NaCN, H_3O^+, HNO_3/H_2SO_4
(c) $Br_2/AlBr_3$, HNO_3/H_2SO_4, NaCN, H_3O^+
(d) HNO_3/H_2SO_4, $Br_2/AlBr_3$, Mg/ether, CO_2, H_3O^+

SECTION - B (NUMERICAL VALUE TYPE)

Attempt any 5 questions out of 10.

21. The number of $4f$ electrons in the ground state electronic configuration of Gd^{2+} is _____.
(Atomic number of Gd = 64)

22. The following data was obtained for chemical reaction given below at 975 K.

$2NO_{(g)} + 2H_{2(g)} \longrightarrow N_{2(g)} + 2H_2O_{(g)}$

	[NO] mol L^{-1}	[H_2] mol L^{-1}	Rate mol L^{-1} s^{-1}
(A)	8×10^{-5}	8×10^{-5}	7×10^{-9}
(B)	24×10^{-5}	8×10^{-5}	2.1×10^{-8}
(C)	24×10^{-5}	32×10^{-5}	8.4×10^{-8}

The order of the reaction with respect to NO is _____.

23. AB_3 is an interhalogen T-shaped molecule. The number of lone pairs of electrons on A is _____.

24. The Born-Haber cycle for KCl is evaluated with the following data:

$\Delta_f H^{\ominus}$ for KCl = –436.7 kJ mol^{-1};
$\Delta_{sub} H^{\ominus}$ for K = 89.2 kJ mol^{-1};
$\Delta_{ionisation} H^{\ominus}$ for K = 419.0 kJ mol^{-1};
$\Delta_{electron\ gain} H^{\ominus}$ for $Cl_{(g)}$ = –348.6 kJ mol^{-1};
$\Delta_{bond} H^{\ominus}$ for Cl_2 = 243.0 kJ mol^{-1}

The magnitude of lattice enthalpy of KCl (in kJ mol^{-1}) is _____.

25. Of the following four aqueous solutions, total number of those solutions whose freezing point is lower than that of 0.10 M C_2H_5OH is _____.

(i) 0.10 M $Ba_3(PO_4)_2$ (ii) 0.10 M Na_2SO_4

(iii) 0.10 M KCl (iv) 0.10 M Li_3PO_4

26. These are physical properties of an element.

(A) Sublimation enthalpy

(B) Ionisation enthalpy

(C) Hydration enthalpy

(D) Electron gain enthalpy

The total number of above properties that affect the reduction potential is _____.

27. The total number of negative charge in the tetrapeptide, Gly-Glu-Asp-Tyr, at pH 12.5 will be _____.

28. The ratio of number of water molecules in Mohr's salt and potash alum is _____ $\times 10^{-1}$.

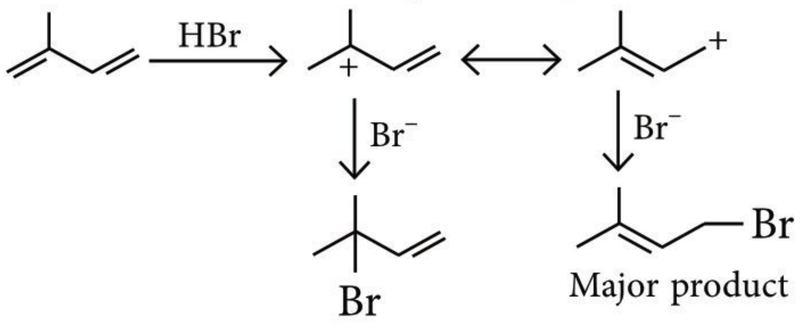
29. The OH^- concentration in a mixture of 5.0 mL of 0.0504 M NH_4Cl and 2 mL of 0.0210 M NH_3 solution is $x \times 10^{-6}$ M. The value of x is _____.
[Given: $K_w = 1 \times 10^{-14}$ and $K_b = 1.8 \times 10^{-5}$]

30. An aqueous KCl solution of density 1.20 g mL^{-1} has a molality of 3.30 mol kg^{-1}. The molarity of the solution in mol L^{-1} is _____.
[Molar mass of KCl = 74.5]

SOLUTIONS

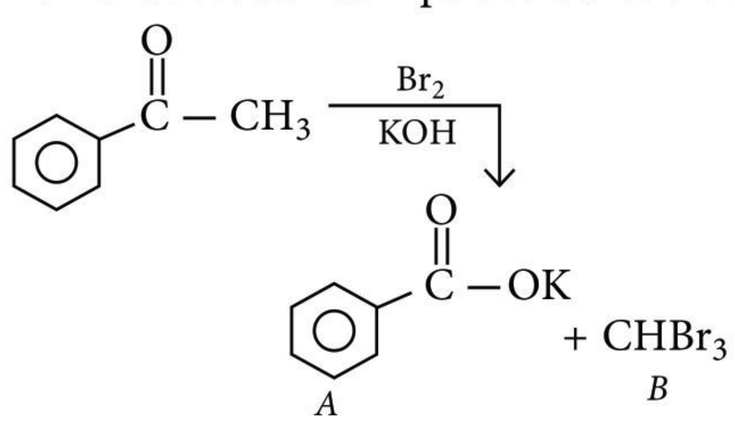
1. **(c) :** Generally, interhalogen compounds are more reactive than halogen (except fluorine). This is because $X - X'$ bond in interhalogens is weaker than $X - X$ bond in halogen except F — F bond.

2. **(c) :**



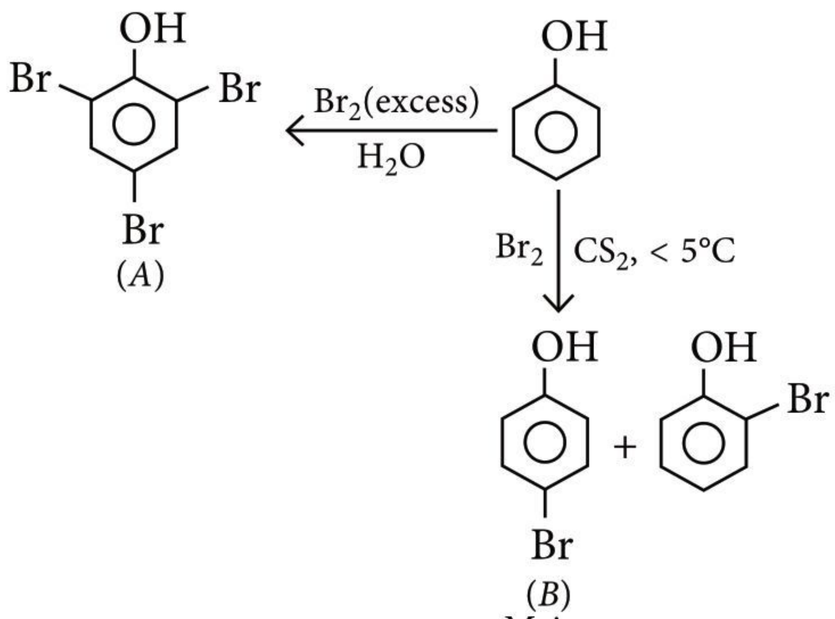
3. **(c) :** Frenkel defect do not impart colour to the solids.

4. **(a) :**



This is haloform reaction.

5. **(d) :**



6. **(d) :** Limiting molar conductivity of KCl is lower than CH_3COOH. Molar conductivity increases with decrease in concentration of electrolyte.

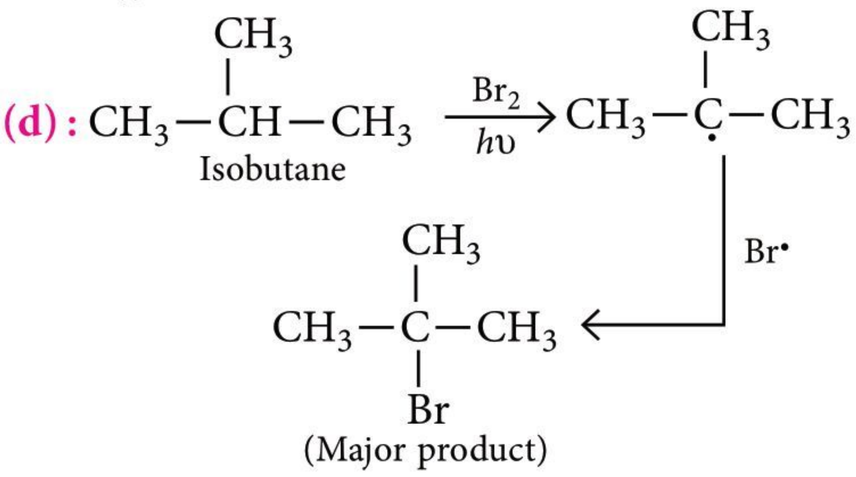
7. **(a) :** Demineralised water is free from all soluble mineral salts. It does not contain any anions or cations. Demineralised water is obtained by passing water successively through a cation exchanger (in the H^+ form) and an anion exchanger (in the OH^- form) resin.

8. **(a) :** According to Bohr's model

$$V_n \propto 2.18 \times 10^6 \frac{Z}{n} \text{ m/s}$$

$$V_n \propto \frac{1}{n} \Rightarrow n \uparrow \; V_n \downarrow$$

9. **(d) :**



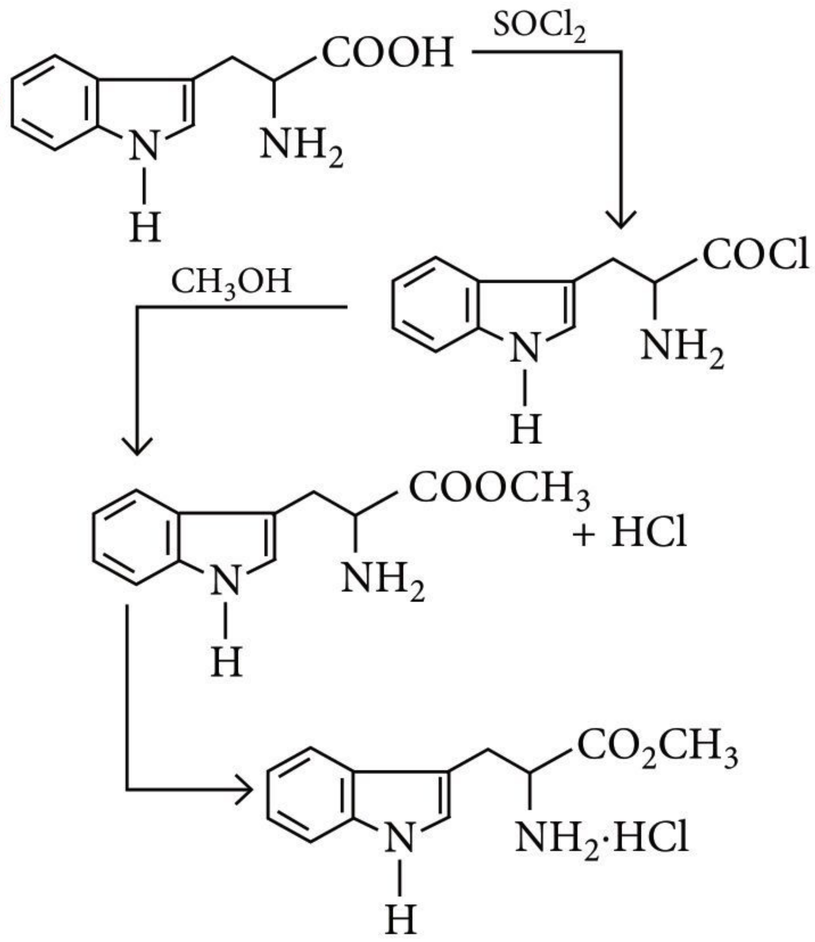
10. **(c) :** AgCl and Cu_2Cl_2 are not dissolved in water $ZnCl_2$ and $CuCl_2$ are dissolved but $ZnCl_2$ is colourless and $CuCl_2$ is coloured.

11. **(d) :** During adsorption, entropy always decreases *i.e.*, $\Delta S < 0$, and during adsorption of gas on solid surface, heat is also evolved *i.e.*, $\Delta H < 0$.

12. **(b) :** Hydroxyapatite is a calcium phosphate mineral with chemical formula $Ca_{10}(PO_4)_6(OH)_2$, *i.e.*, $[3Ca_3(PO_4)_2 \cdot Ca(OH)_2]$

13. **(d) :** Methyl orange is a good chemical indicator in strong acid and weak base titration as it changes its yellow colour in basic to red colour in acidic medium. Phenolphthalein is used as indicator for weak acid and strong base titration as it changes colour between pH range 8 to 10.

14. (b) :

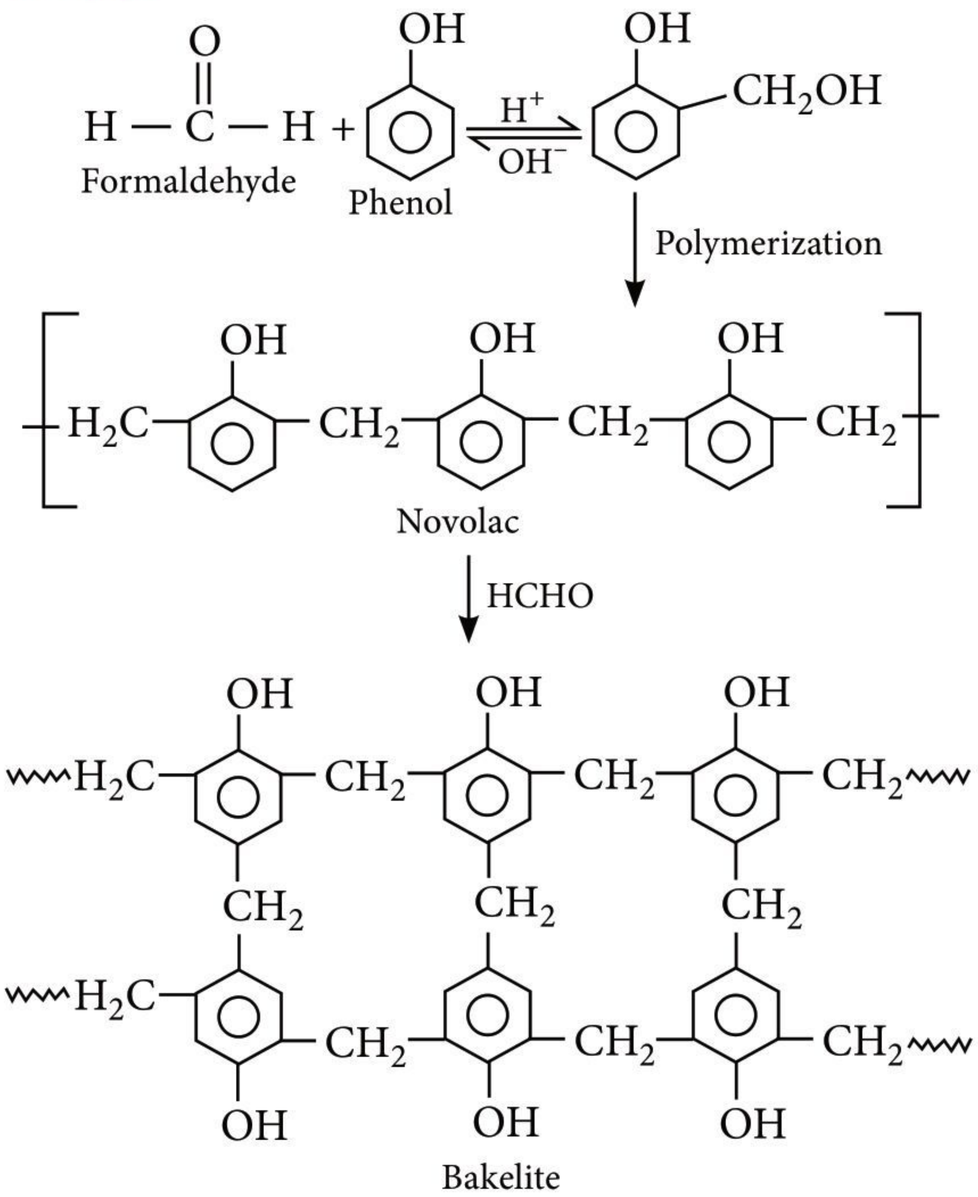


15. (d) : In I, II and III halogen is directly bonded to benzene ring hence it cannot be removed due to partial double bond character of C — Cl bond. In IV, $-CH_2I$ group is also present so it will give yellow precipitate of AgI.

16. (c) : $Ca(OH)_2 + CO_2 \longrightarrow \underset{\text{(Milkiness)}}{CaCO_3} + H_2O$

$CaCO_3 + H_2O + \underset{\text{Excess}}{CO_2} \longrightarrow \underset{\text{Soluble}}{Ca(HCO_3)_2}$

17. (b) :



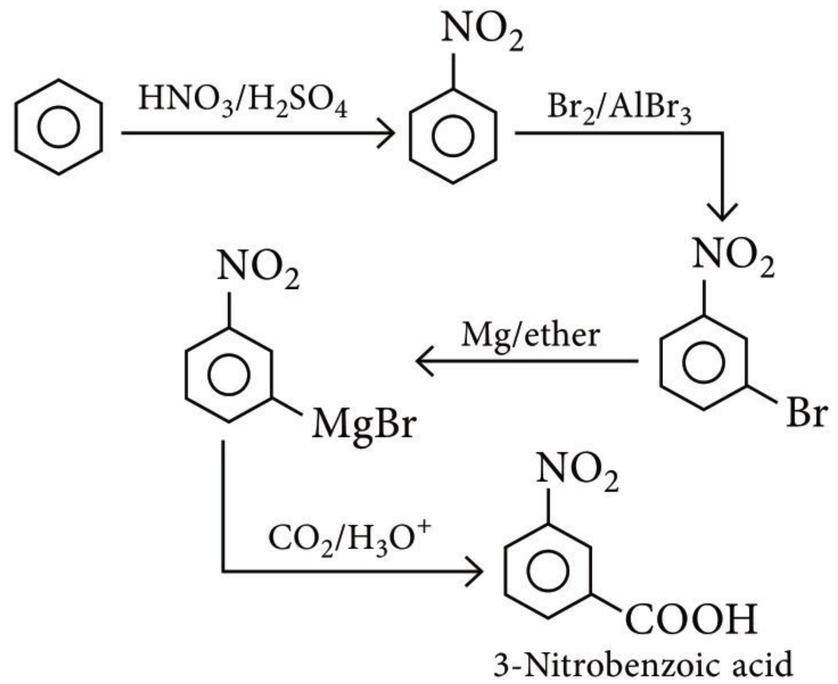
18. (c)

19. (b) : $S^{2-} + Na_2[Fe(CN)_5(NO)] \longrightarrow$

$Na_4[Fe(CN)_5(NOS)]$

Violet colour

20 (d) :



21. (7) : $Gd^{2+} : [Xe]4f^7 5d^1\ 6s^0$

22. (1) : Rate $\propto [NO]^x\ [H_2]^y$

$\text{Rate}_1 = [8 \times 10^{-5}]^x\ [8 \times 10^{-5}]^y = 7 \times 10^{-9}$ ...(i)

$\text{Rate}_2 = [24 \times 10^{-5}]^x\ [8 \times 10^{-5}]^y = 2.1 \times 10^{-8}$ ...(ii)

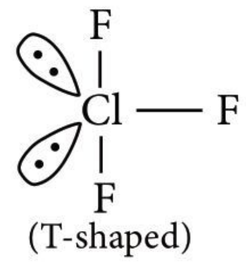
$\text{Rate}_3 = [24 \times 10^{-5}]^x\ [32 \times 10^{-5}]^y = 8.4 \times 10^{-8}$ ...(iii)

From eq. (i) and (ii)

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \frac{2.1\times10^{-8}}{7\times10^{-9}} = \frac{[24\times10^{-5}]^x[8\times10^{-5}]^y}{[8\times10^{-5}]^x\,[8\times10^{-5}]^y}$$

$3 = [3]^x \Rightarrow n = 1$

23. (2) : AB_3 is T-shaped hence, it may be ClF_3.



(T-shaped)

24. (718) : $\Delta H_{\text{formation}}$ can be given as

$$\Delta_f H^\circ_{(KCl)} = \Delta_{sub}H^\circ_{(K)} + \Delta_{ion}H^\circ_{(K)} + \frac{1}{2}\Delta_{bond}H^\circ_{(Cl_2)}$$

$$+ \Delta_{e.g.}H^\circ_{(Cl)} + \Delta_{lattice}H^\circ_{(KCl)}$$

$$\Delta_{lattice}H^\circ_{(KCl)} = \Delta_f H^\circ_{(KCl)} - \Delta_{sub}H^\circ_{(K)} - \Delta_{ion}H^\circ_{(K)}$$

MONTHLY TEST DRIVE CLASS XI ANSWER KEY

1.	(b)	**2.**	(a)	**3.**	(b)	**4.**	(b)	**5.**	(a)
6.	(a)	**7.**	(d)	**8.**	(d)	**9.**	(a)	**10.**	(d)
11.	(b)	**12.**	(c)	**13.**	(d)	**14.**	(c)	**15.**	(a)
16.	(a)	**17.**	(c)	**18.**	(c)	**19.**	(d)	**20.**	(b,d)
21.	(a,d)	**22.**	(b,c,d)	**23.**	(b,d)	**24.**	(8.4)	**25.**	(30)
26.	(3)	**27.**	(b)	**28.**	(d)	**29.**	(b)	**30.**	(c)

$$= -\frac{1}{2}\Delta_{bond}H^{\circ}_{(Cl_2)} - \Delta_{e.g}H^{\circ}_{(Cl)}$$

$$= -436.7 - 89.2 - 419.0 - \frac{1}{2}(243) - (-348.6)$$

$$= -717.8 \approx 718 \text{ kJ/mol}$$

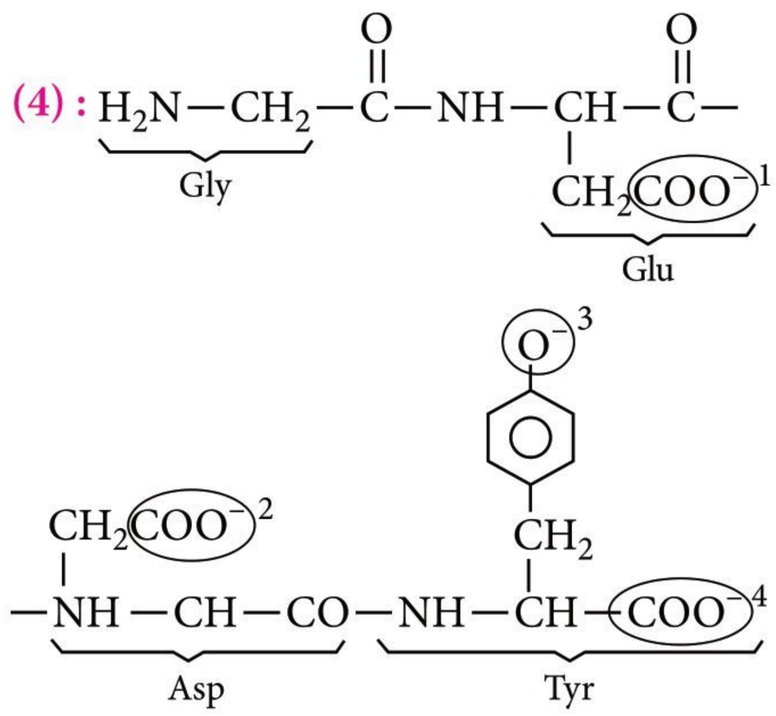
25. (4) : Higher the number of ions in solution (as the conc. is same), more will be the depression in freezing point and lower will be the freezing point.

Molecule	Number of ions (i)
C_2H_5OH	1
$Ba_3(PO_4)_2$	5
Na_2SO_4	3
KCl	2
Li_3PO_4	4

As all the given molecules have higher number of ions therefore, all will have lower freezing point.

26. (3) : Electrode potential depends upon; enthalpy of sublimation, ionisation and hydration.

27. (4) :



28. (5) : Mohr's salt = $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$

Potash alum = $KAl(SO_4)_2.12H_2O$

$$\text{Water molecule ratio} = \frac{6}{12} = \frac{1}{2} = 5 \times 10^{-1}$$

29. (3) : $[NH_4^+] = 0.0504$ M, $V = 5.0$ mL

$[NH_3] = 0.0210$ M, $V = 2.0$ mL

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} \Rightarrow [OH^-] = \frac{K_b[NH_3]}{[NH_4^+]}$$

$$[OH^-] = \frac{(1.8 \times 10^{-5}) \times 0.0210 \times 2}{0.0504 \times 5}$$

$$= 3 \times 10^{-6} \text{ M}$$

30. (3.17) : $$\text{Molality } (m) = \frac{M \times 1000}{(1000 \times d) - (M \times M_{solute})}$$

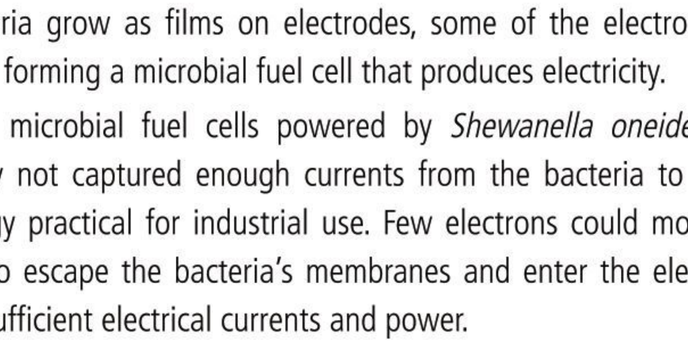
$$3.3 = \frac{M \times 1000}{1000 \times 1.2 - M \times 74.5}$$

$3960 - 245.85\ M = 1000\ M$

$1245.65\ M = 3960$

$$M = \frac{3960}{1245.85} = 3.17 \text{ M}$$

For the SCIENTIST in YOU



Researchers infuse bacteria with silver to improve power efficiency in fuel cells!

Living energy-recovery systems utilizing bacteria found in wastewater, offer a one-two punch for environmental sustainability efforts.The natural populations of bacteria can help decontaminate groundwater by breaking down harmful chemical compounds. Now, the research also shows a practical way to harness renewable energy from this process.

The team focused on the bacteria genus *Shewanella*, which have been widely studied for their energy-generation capabilities. They can grow and thrive in all types of environments – including soil, wastewater and seawater, regardless of oxygen levels.

Shewanella species naturally break down organic waste matter into smaller molecules, with electrons being a byproduct of the metabolic process. When the bacteria grow as films on electrodes, some of the electrons can be captured, forming a microbial fuel cell that produces electricity.

However, microbial fuel cells powered by *Shewanella oneidensis* have previously not captured enough currents from the bacteria to make the technology practical for industrial use. Few electrons could move quickly enough to escape the bacteria's membranes and enter the electrodes to provide sufficient electrical currents and power.

To address this issue, the researchers added nanoparticles of silver to electrodes that are composed of a type of graphene oxide. The nanoparticles release silver ions, which bacteria reduce to silver nanoparticles using electrons generated from their metabolic process and then incorporate into their cells. Once inside the bacteria, the silver particles act as microscopic transmission wires, capturing more electrons produced by the bacteria.

With greatly improved electron transport efficiency, the resulting silver-infused *Shewanella* film outputs more than 80% of the metabolic electrons to external circuit, generating a power of 0.66 milliwatts per square centimeter – more than double the previous best for microbial-based fuel cells.

BRUSH UP for NEET/JEE CLASS-XI

Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

Unit 4

Equilibrium | Redox Reactions

Equilibrium

At equilibrium, two opposing processes (forward and reverse) take place at equal rates hence it is called dynamic equilibrium.

Equilibria Involving Physical Processes

Type	Name	Equilibrium	Constant value at equilibrium
Solid-Liquid	Fusion	$H_2O_{(s)} \rightleftharpoons H_2O_{(l)}$	Melting point at constant pressure
Liquid-Gas	Vaporisation	$H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$	Vapour pressure of H_2O at constant temperature
Solid-Gas	Sublimation	$NH_4Cl_{(s)} \rightleftharpoons NH_4Cl_{(g)}$	Vapour pressure of NH_4Cl at constant temperature
Solid-Liquid	Dissolution	$Sugar_{(s)} \rightleftharpoons$ Sugar (in solution)	Solubility at constant temperature
Gas-Liquid	Dissolution	$CO_{2(g)} \rightleftharpoons CO_2$ (in solution)	Ratio of concentration of $CO_{2(aq)}$ and $CO_{2(g)}$ at constant temperature and pressure

Equilibria Involving Chemical Processes

- **Law of chemical equilibrium :** Law of chemical equilibrium is a result obtained by applying the law of mass action to a reversible reaction in equilibrium.
- For example, consider a general reversible reaction, $aA + bB \rightleftharpoons cC + dD$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$; where, K_c is equilibrium constant.

- For a gas phase reaction, $aA + bB \rightleftharpoons cC + dD$

$$K_p = \frac{(p_C)^c(p_D)^d}{(p_A)^a(p_B)^b} \quad \text{and} \quad K_p = K_c(RT)^{\Delta n};$$

where, $\Delta n = (n_{\text{gaseous products}} - n_{\text{gaseous reactants}})$

Quotable Quote

"The way to get good ideas is to get lots of ideas and throw the bad ones away."

Linus Pauling

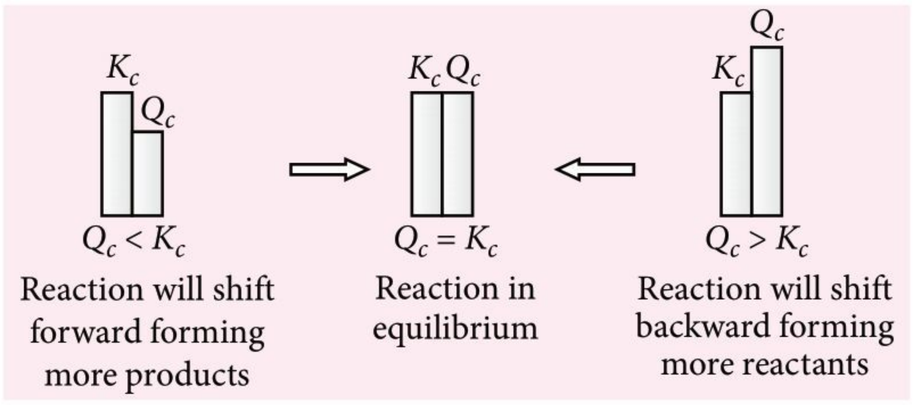
- If $\Delta n_g = 0$, $K_p = K_c$
- If Δn_g = + ve (*i.e.*, $n_p > n_r$), $K_p > K_c$
- If Δn_g = –ve (*i.e.*, $n_p < n_r$), $K_p < K_c$

Predicting the Direction of the Reaction

$$aA + bB \rightleftharpoons cC + dD$$

Reaction Quotient, $Q_c = \dfrac{[C]^c[D]^d}{[A]^a[B]^b}$

at any stage other than the equilibrium.



Characteristics of equilibrium constant : For a reaction, $A + B \rightleftharpoons C + D$, Equilibrium constant, $K = \dfrac{[C][D]}{[A][B]}$

Characteristics	Reaction	Equilibrium constant
If reaction is reversed.	$C + D \rightleftharpoons A + B$	$K' = 1/K$
If reaction is divided by factor n.	$\frac{1}{n}A + \frac{1}{n}B \rightleftharpoons \frac{1}{n}C + \frac{1}{n}D$	$K' = \sqrt[n]{K}$
If reaction is multiplied by factor n.	$nA + nB \rightleftharpoons nC + nD$	$K' = K^n$
If reaction is written in n number of steps.	$A + B \overset{K_1}{\rightleftharpoons} X + Y$; $X + Y \overset{K_2}{\rightleftharpoons}$ $P + Q \ldots \overset{K_n}{\rightleftharpoons} C + D$	$K' = K_1 \times K_2 \times \ldots K_n$

Effect of Temperature on Equilibrium Constant

$$\frac{d \ln K_p}{dT} = \frac{\Delta H^\circ}{RT^2} \; ; \; \log \frac{K_2}{K_1} = \frac{\Delta H^\circ}{2.303R}\left[\frac{T_2 - T_1}{T_1 T_2}\right]$$

- For endothermic reactions, the equilibrium constant increases (k_f increases more than k_b) with rise in temperature and decreases with decrease in temperature.
- For exothermic reactions, equilibrium constant decreases (k_b increases more than k_f) with rise in temperature and increases with fall in temperature.

Le Chatelier's Principle

If a system in equilibrium is subjected to a change of concentration, temperature or pressure, the equilibrium shifts in a direction so as to undo the effect of the change imposed.

Effect on Chemical Equilibria	
Type of Effect or Change	**Direction of Equilibrium**
Addition of one or more reactants	Forward direction
Addition of one or more products	Backward direction
Increase in pressure	Where the number of gaseous moles are less
Decrease in pressure	Where the number of gaseous moles are more
Addition of catalyst	No effect
Addition of inert gas at constant volume	No effect
Addition of inert gas at constant pressure	Where the number of gaseous moles are more

Equilibrium constant and free energy change :

$\Delta G = \Delta G^\circ + RT \ln Q_c$

At equilibrium, $\Delta G = 0$, $Q_c = K_c$

$\Delta G^\circ = -2.303RT \log K_c$ (van't Hoff isotherm)

When $K_c = 1$, $\Delta G^\circ = 0$ (Reaction is in equilibrium.)

When $K_c > 1$, ΔG° = –ve

(Forward reaction is favoured.)

When $K_c < 1$, ΔG° = +ve (Backward reaction is favoured.)

Ionic Equilibrium

A substance whose aqueous solution or melt conducts electricity is called *electrolyte* while a

substance whose aqueous solution or melt does not conduct electricity is called *non-electrolyte*.

- **Degree of dissociation (α) :**
  - For strong electrolytes, $\alpha = 1$.
  - For weak electrolytes, $\alpha < 1$.
- **Ostwald's dilution law :** For the reaction,

$$\underset{\text{Initially :}}{AB} \rightleftharpoons \underset{c}{A^+} + \underset{0}{B^-}$$

$$\underset{\text{At equilibrium :}}{} \quad \underset{c(1-\alpha)}{} \quad \underset{c\alpha}{} \quad \underset{c\alpha}{}$$

So, dissociation constant may be given as :

$$K = \frac{[A^+][B^-]}{[AB]} = \frac{c\alpha \times c\alpha}{c(1-\alpha)} = \frac{c\alpha^2}{(1-\alpha)} \quad \text{... (i)}$$

For very weak electrolytes,

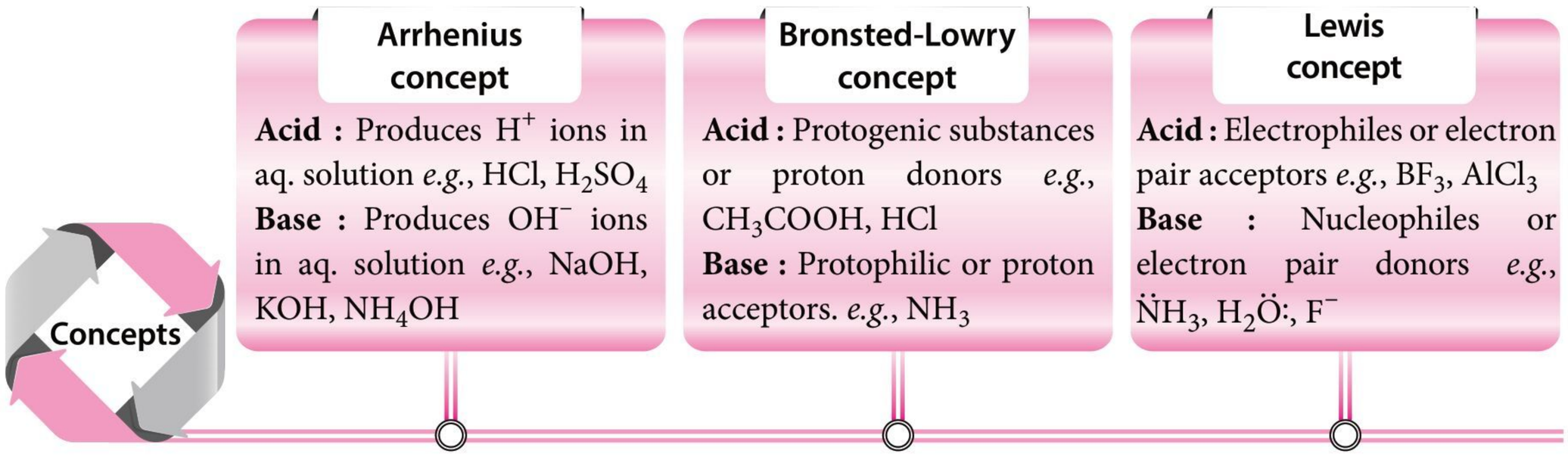
$\alpha <<< 1$, $(1 - \alpha) \approx 1$

$\therefore \quad K = c\alpha^2$

$$\alpha = \sqrt{\frac{K}{c}} \quad \text{...(ii)}$$

Concentration of any ion = $c\alpha = \sqrt{cK}$

- **Various concepts of acids and bases :**



Conjugate Acid-Base Pair

- A pair of acid and base, which differs by a proton is known as conjugate acid-base pair.

$$\underset{\text{Acid}}{} + \underset{\text{Base}}{} \rightleftharpoons \underset{\text{Conjugate Base}}{} + \underset{\text{Conjugate Acid}}{}$$

($-H^+$: Base → Conjugate Base; $+H^+$: Conjugate Acid → Acid)

Ionization of Acids and Bases

- $\underset{\text{(Acid)}}{HA} \rightleftharpoons H^+ + A^-$,

$$K_a = \frac{[H^+][A^-]}{[HA]} \text{ and } \alpha = \sqrt{\frac{K_a}{c}}$$

$\underset{\text{Base}}{BOH} \rightleftharpoons B^+ + OH^-$,

$$K_b = \frac{[B^+][OH^-]}{[BOH]} \text{ and } \alpha = \sqrt{\frac{K_b}{c}}$$

- **Relation between K_a and K_b :**

For a weak acid, $pK_a = -\log K_a$;

For a weak base, $pK_b = -\log K_b$

$pK_a + pK_b = pK_w = 14$ at 298 K

- **The ionic product of water :**

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 298 K, where K_w is the ionic product of water.

The ionic product of water is constant only at constant temperature. With increase of temperature, the degree of ionization of water increases. Thus the concentration of H^+ and OH^- increases and hence the ionic product also increases.

- **The pH scale :** The pH of a solution is a measure of the acidity of a solution.

$pH = -\log[H^+]$

If pH < 7, acidic solution; if pH = 7, neutral solution; if pH > 7, basic solution. $pK_w = pH + pOH = 14$

Calculation of pH

	Types of solution	Formula
1.	Dilute aqueous solution of a strong acid or a strong base	$pH = -\log\{[H^+]_{acid} + [H^+]_{H_2O}\}$ $pOH = -\log\{[OH^-]_{base} + [OH^-]_{H_2O}\}$

2.	Highly concentrated solution of a strong acid or a strong base (concentration > 1 M)	pH of acidic solution is taken as 0. pH of basic solution is taken as 14.
3.	Solution of a weak acid or a weak base	$pH = -\log(C\alpha) = -\log(\sqrt{K_a C})$ $pOH = -\log(C\alpha) = -\log(\sqrt{K_b C})$
4.	Mixture of two or more strong monoprotic acids or strong bases	$pH = -\log\left(\frac{\Sigma NV}{\Sigma V}\right)$, $pOH = -\log\left(\frac{\Sigma NV}{\Sigma V}\right)$
5.	Mixture of an acid and a base	$pH = -\log\left(\frac{(N_1V_1)_{acid} - (N_2V_2)_{base}}{V_1 + V_2}\right)$ (if acid is in excess) $pOH = -\log\left(\frac{(N_2V_2)_{base} - (N_1V_1)_{acid}}{V_1 + V_2}\right)$ (if base is in excess)
6.	Amphiprotic system	$pH = \frac{pK_{a_1} + pK_{a_2}}{2}$

Salt Hydrolysis

Salts of strong acid and strong base do not undergo hydrolysis and the resulting solution is neutral.

Salt	Hydrolysis	Resulting solution	Hydrolysis constant (K_h)	Degree of hydrolysis (h)	pH
Weak acid and Strong base	Anionic	Alkaline pH > 7	$K_h = \frac{K_w}{K_a}$	$h = \sqrt{\frac{K_h}{C}}$	$pH = \frac{1}{2}[pK_w + pK_a + \log C]$
Strong acid and Weak base	Cationic	Acidic pH < 7	$K_h = \frac{K_w}{K_b}$	$h = \sqrt{\frac{K_h}{C}}$	$pH = \frac{1}{2}[pK_w - pK_b - \log C]$
Weak acid and Weak base	Anionic and cationic both	Neutral, pH = 7 (If $K_a = K_b$)	$K_h = \frac{K_w}{K_a K_b}$	$h = \sqrt{K_h}$	$pH = \frac{1}{2}[pK_w + pK_a - pK_b]$

Solubility product : It is defined as the product of the molar concentrations of ions of an electrolyte in a saturated solution, each concentration raised to the power equal to the number of ions produced on dissociation of one molecule of the electrolyte.

$A_xB_y \rightleftharpoons xA^{y+} + yB^{x-}$; $K_{sp} = [A^{y+}]^x[B^{x-}]^y$

Types of Salt

Binary electrolyte 1 : 1 (AB)	Ternary electrolyte 1 : 2 (AB_2)	Ternary electrolyte 2 : 1 (A_2B)	Quaternary electrolyte 1 : 3 (AB_3)	3 : 2 (A_3B_2)
e.g., AgCl, $BaSO_4$, etc.	*e.g.*, $PbCl_2$, $Ca(OH)_2$, etc.	*e.g.*, Ag_2CrO_4, Ag_2CO_3, etc.	*e.g.*, $Fe(OH)_3$, $Al(OH)_3$, etc.	*e.g.*, $Ca_3(PO_4)_2$, $Ba_3(PO_4)_2$, etc.
$s = \sqrt{K_{sp}}$	$s = \sqrt[3]{K_{sp}/4}$	$s = \sqrt[3]{K_{sp}/4}$	$s = \sqrt[4]{K_{sp}/27}$	$s = \sqrt[5]{K_{sp}/108}$
or $K_{sp} = s^2$	or $K_{sp} = 4s^3$	or $K_{sp} = 4s^3$	or $K_{sp} = 27s^4$	or $K_{sp} = 108s^5$

Buffer Solutions

The property of resisting change in pH of a solution when an acid or an alkali is added to it in small amount is known as buffer action and such solutions are called buffer solutions.

Henderson-Hasselbalch equation

For acidic buffer : $pH = pK_a + \log\frac{[Salt]}{[Acid]}$

- **For basic buffer :** $pOH = pK_b + \log \frac{[Salt]}{[Base]}$

  or, $pH = pK_a + \log \frac{[Base]}{[Salt]}$

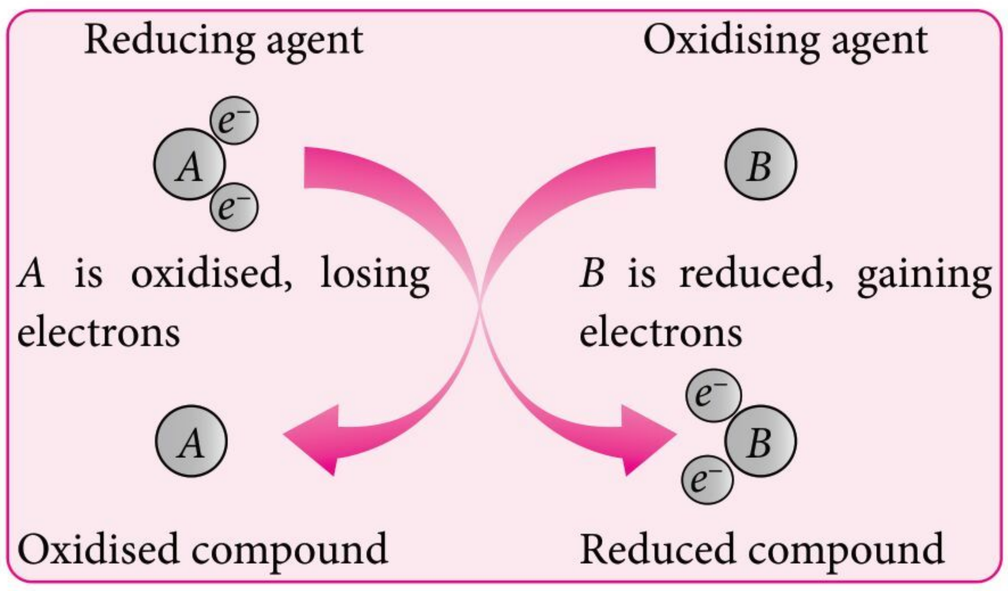
  - On dilution, the ratio of concentrations of salt and acid or salt and base will still remain same thus pH will remain unchanged.

- **Buffer capacity :** It is the number of moles of an acid or a base added to change pH of one litre of a buffer solution by one unit.
  Hence, buffer capacity

$$= \frac{\text{Number of moles of acid or base added per litre of buffer}}{\text{Change in pH}} = \frac{dn}{d(pH)}$$

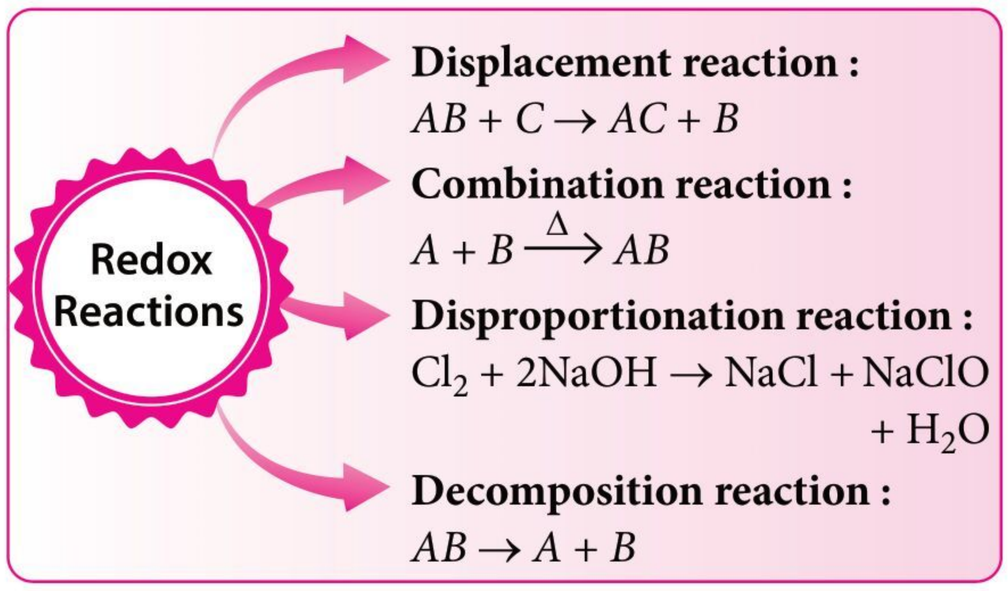
Redox Reactions

- Chemical reactions which involves the transfer of electrons from one chemical substance to another are called *Redox* or *oxidation-reduction reactions.*
- **Oxidation :**
  - Addition of Oxygen
  - Removal of Hydrogen
  - Addition of an electronegative element or group
  - Removal of an electropositive element or group
  - Increase in valency of an electropositive element
  - Loss of electrons by an atom or ion
- **Reduction :**
  - Removal of Oxygen
  - Addition of hydrogen
  - Removal of an electronegative element or group
  - Addition of an electropositive element or group
  - Decrease in valency of electropositive element
  - Gain of one or more electrons by an atom or ion



Oxidation Number Rules

Rules	Oxidation no.	Examples
Atoms of different elements in elementary state and in allotropic form.	zero (0)	N_2, Cl_2, O_2, P_4, S_8
Monoatomic ions	same as charge	$Na^+(1)$, $Mg^{2+}(2)$, $Cl^-(-1)$
Hydrogen : - with non-metals - with metals	 +1 −1	 H_2O, H_2S, HCl LiH, CaH_2, KH
Oxygen : - in peroxides - with fluorine - in superoxides	−2 (mostly) −1 +1, +2 −1/2	H_2O, CaO, NaOH H_2O_2, BaO_2 O_2F_2, OF_2 KO_2, RbO_2
Alkali metal (IA)	+1	Li, Na, K, etc.
Alkaline earth metals (IIA)	+2	Be, Mg, Ca, etc.
Fluorine (most electronegative)	−1 (always)	HF, OF_2, LiF



Balancing of Redox Reactions

Oxidation Number Method

- Identify atoms which undergo change in oxidation number in the reaction.
- Calculate the increase or decrease in the oxidation number per atom and multiply it by number of atoms undergoing that change, if increase or decrease is not equal then multiply by suitable number to make them equal.

- Add H^+ (if medium is acidic) or OH^- (if medium is basic) on the appropriate side so that the total ionic charges of reactants and products are equal.
- Make the number of hydrogen atoms in the expression on the two sides equal by adding H_2O to the reactants or products and finally check the number of oxygen atoms.

Half Reaction Method

- Separate the equation into half-reactions.
- Balance the atoms other than O and H in each half-reaction individually.
- For reactions occurring in acidic medium, add H_2O to balance O atoms and H^+ to balance H atoms and for basic medium, H atoms are balanced by adding H_2O molecule to the side deficient in H atoms and equal number of OH^- ions are added to opposite side and then duplicacy is removed if any.
- Add electrons to one side of the half-reaction to balance the charges and make the number of electrons equal in two half-reactions by multiplying one or both half-reactions by appropriate number.
- Add two half-reactions to achieve the overall reaction and cancel the electrons on both sides.

Equivalent Mass

- Equivalent weight of oxidant/reductant = $\frac{\text{Formula weight}}{\text{Total change in oxidation number}}$
- For a disproportionation reaction, equivalent mass of oxidant/reductant.
= sum of equivalent mass of two half reactions.

$$e.g.,\ \overset{(+3)}{4H_3PO_3} \longrightarrow \overset{(+5)}{3H_3PO_4} + \overset{(-3)}{PH_3}$$

$$\text{Eq. mass of } H_3PO_3 = \frac{M}{2} + \frac{M}{6} = \frac{2M}{3}$$

Redox Reactions and Electrode Processes

- **Redox couple :** It is defined as having together the oxidised and reduced forms of a substance taking part in an oxidation or reduction half-reaction *i.e*, a metal dipped in the solution of its own ions.
- **Electrode potential :** The potential difference set up between the metal and its own ions in the solution is called the electrode potential. In general, it is the tendency of an electrode to gain or lose electrons.
- **Standard electrode potential ($E°$) :** If the concentration of each species taking part in the electrode reaction is unity and further the reaction is carried out at 298 K, then the potential of each electrode is called standard electrode potential.
  - Standard electrode potential of hydrogen is taken as 0.00 volts by convention.
  - **Electrochemical series** is a series in which a list of oxidising agents are arranged in decreasing order of their strength. It is also called **activity** or **electromotive series**.
  - A negative $E°$ means that the redox couple is a stronger reducing agent than the H^+/H_2 couple.
  - A positive $E°$ means that the redox couple is a weaker reducing agent than the H^+/H_2 couple.

WRAP it up!

MCQs Type

1. Using the standard electrode potential, find out the pair between which redox reaction is not feasible.
[$E°$ values : Fe^{3+}/Fe^{2+} = + 0.77 V; I_2/I^- = + 0.54 V; Cu^{2+}/Cu = + 0.34 V; Ag^+/Ag = + 0.80 V]
(a) Fe^{3+} and I^- (b) Ag^+ and Cu
(c) Fe^{3+} and Cu (d) Ag and Fe^{3+}

2. The solubility of different sparingly soluble salts are given as follows:

S. No.	Formula Type	Solubility product
1.	AB	4.0×10^{-20}
2.	A_2B	3.2×10^{-11}
3.	AB_3	2.7×10^{-31}

The correct increasing order of solubility is
(a) 1, 3, 2 (b) 2, 1, 3 (c) 1, 2, 3 (d) 3, 1, 2

3. What is the equivalent weight of NH_3 in the given reaction?
$3CuO + 2NH_3 \longrightarrow 3Cu + N_2 + 3H_2O$
(a) 17 (b) 17/4 (c) 17/2 (d) 17/3

4. From the given data, identify the most stable oxide of nitrogen.

$2NO_{2(g)} \rightleftharpoons N_{2(g)} + 2O_{2(g)}$; $K = 6.7 \times 10^{16}$ mol L^{-1}

$2N_2O_{5(g)} \rightleftharpoons 2N_{2(g)} + 5O_{2(g)}$; $K = 1.2 \times 10^{24}$ mol^5 L^{-5}

$2NO_{(g)} \rightleftharpoons N_{2(g)} + O_{2(g)}$; $K = 2.2 \times 10^{30}$

$2N_2O_{(g)} \rightleftharpoons 2N_{2(g)} + O_{2(g)}$; $K = 3.5 \times 10^{33}$ mol L^{-1}

(a) N_2O (b) NO (c) N_2O_5 (d) NO_2

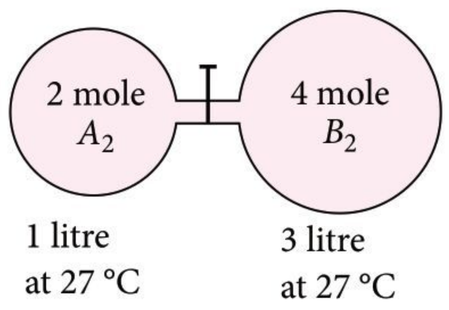
5. What is the change in oxidation number of carbon in the following reaction?

$CH_{4(g)} + 4Cl_{2(g)} \rightarrow CCl_{4(l)} + 4HCl_{(g)}$

(a) + 4 to + 4 (b) 0 to + 4

(c) – 4 to + 4 (d) 0 to – 4 *(NEET 2020)*

6. The gas A_2 in the left flask allowed to react with gas B_2 present in right flask as $A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$; $K_c = 4$ at 27 °C.



What is the concentration of AB when equilibrium is established ?

(a) 1.33 M (b) 2.66 M

(c) 0.66 M (d) 0.33 M

7. For the reaction,

$3Br_2 + 6OH^- \longrightarrow 5Br^- + BrO_3^- + 3H_2O$

equivalent weight of Br_2 (if molecular weight is 'M') is

(a) $\frac{M}{2}$ (b) $\frac{M}{10}$

(c) $\left(\frac{M}{2} + \frac{M}{10}\right)$ (d) $\left(\frac{M}{6}\right)$

8. A mixture of 1.57 moles of N_2, 1.92 moles of H_2 and 8.13 moles of NH_3 is introduced into a 20 L reaction vessel at 500 K. At this temperature, the equilibrium constant, K_c for the reaction, $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ is 1.7×10^2.

Select the true statement.

(a) The reaction is at equilibrium.

(b) The reaction goes in the direction of reactants.

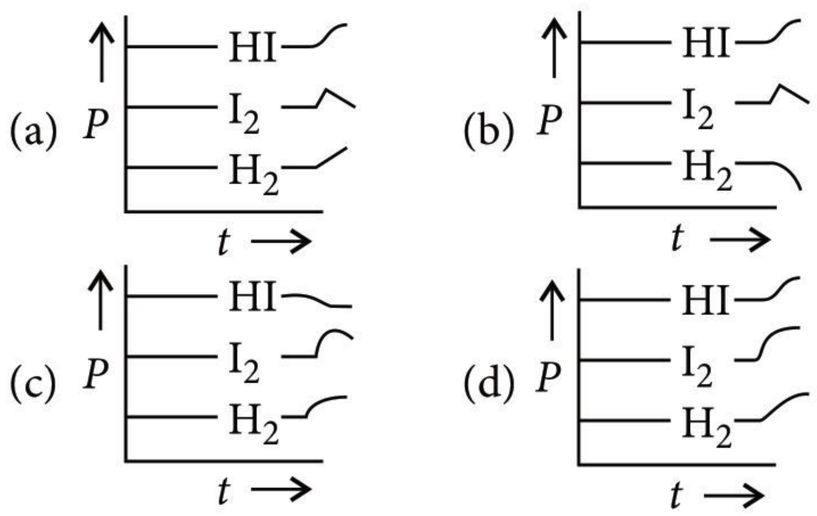
(c) The reaction goes in the direction of product.

(d) None of these.

9. Consider the gaseous equilibrium of

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

The three gases are at equilibrium in a container as shown in the following graphs. At some time t, extra I_2 is added. Which of the following sets will respond to this situation?



10. Match the following species with the corresponding conjugate acid.

Species	Conjugate acid
(i) NH_3	(a) CO_3^{2-}
(ii) HCO_3^-	(b) NH_4^+
(iii) H_2O	(c) H_3O^+
(iv) HSO_4^-	(d) H_2SO_4
	(e) H_2CO_3

(a) (i) → (e), (ii) → (a), (iii) → (b), (iv) → (c)

(b) (i) → (b), (ii) → (e), (iii) → (c), (iv) → (d)

(c) (i) → (c), (ii) → (d), (iii) → (b), (iv) → (a)

(d) (i) → (b), (ii) → (d), (iii) → (e), (iv) → (a)

11. At 627°C and one atmospheric pressure, SO_3 is partially dissociated into SO_2 and O_2 as

$SO_{3(g)} \rightleftharpoons SO_{2(g)} + 1/2O_{2(g)}$

The density of the equilibrium mixture is found to be 0.925 g L^{-1}. The degree of dissociation of SO_3 under these conditions is

(a) 8.5% (b) 17% (c) 34% (d) 68%

12. In the following reaction :

$M^{x+} + MnO_4^- \longrightarrow MO_3^- + Mn^{2+} + 1/2\ O_2$,

if one mole of MnO_4^- oxidises 2.5 moles of M^{x+}, then the value of x is

(a) 5 (b) 3 (c) 4 (d) 2

13. pH of a saturated solution of $Ca(OH)_2$ is 9. The solubility product (K_{sp}) of $Ca(OH)_2$ is

(a) 0.5×10^{-10} (b) 0.5×10^{-15}

(c) 0.25×10^{-10} (d) 0.125×10^{-15}

(NEET 2019)

14. Buffer capacity of a buffer solution is x, the volume of 1 M NaOH added to 100 mL of this solution for the change of pH by 1 is

(a) 0.1 x mL (b) 10 x mL

(c) 100 x mL (d) x mL.

15. Zn salt is mixed with $(NH_4)_2S$ of molarity = 0.021 M, what amount of Zn^{2+} will remain unprecipitated in 12 mL of the solution? [K_{sp} of ZnS = 4.51×10^{-24}]

(a) 4.232×10^{-20} g (b) 1.677×10^{-22} g

(c) 1.999×10^{-18} g (d) 6.201×10^{-22} g

16. For the following reactions, equilibrium constants are given :

$S_{(s)} + O_{2(g)} \rightleftharpoons SO_{2(g)}$; $K_1 = 10^{52}$

$2S_{(s)} + 3O_{2(g)} \rightleftharpoons 2SO_{3(g)}$; $K_2 = 10^{129}$

The equilibrium constant for the reaction,

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ is

(a) 10^{154} (b) 10^{77} (c) 10^{181} (d) 10^{25}

(JEE Main 2019)

17. A compound contains atoms X, Y and Z. The oxidation number of X is +2, Y is +5 and Z is −2. The possible formula of the compound is

(a) XYZ_2 (b) $Y_2(XZ_3)_2$

(c) $X_3(YZ_4)_2$ (d) $X_3(Y_4Z)_2$

18. Which of the following is the strongest reducing agent in aqueous medium?

(a) Mg (b) Na (c) Li (d) Ca

19. The pH of an acid buffer can be raised by 2 units by

(a) increasing the concentration of both weak acid and salt by two moles

(b) increasing the concentration of both the acid and salt by 10 times.

(c) diluting the solution by 10 times

(d) increasing the concentration of the salt by 10 times and decreasing concentration of the acid by 10 times.

20. If for the given reactions, the equilibrium constants (K) are : $A_2 + B_2 \longrightarrow C$, $K = 4$,

$C + 2B_2 \longrightarrow 2D_2 = 16$ then match the reactions given in column I with the equilibrium constant values given in column II.

Choose the correct option from the codes given below.

	Column I	Column II	
P.	$\frac{1}{2}A_2 + \frac{3}{2}B_2 \longrightarrow D_2$	1.	$\frac{1}{4}$
Q.	$2D_2 \longrightarrow A_2 + 3B_2$	2.	64
R.	$A_2 + 3B_2 \longrightarrow 2D_2$	3.	$\frac{1}{64}$
S.	$D_2 \longrightarrow B_2 + \frac{1}{2}C$	4.	8

	P	Q	R	S
(a)	1	2	3	4
(b)	1	3	2	4
(c)	4	2	3	1
(d)	4	3	2	1

21. Small quantities of aqueous solution of X_2, Y_2 and Z_2 are put separately in three test tubes. Now, small quantities of compounds AX, AY and AZ are added separately to each of the solution of X_2, Y_2 and Z_2. AX does not react with any of the three solutions. AY reacts with both X_2 and Z_2. AZ reacts with X_2. The decreasing order of ease of oxidation of the anions X^-, Y^- and Z^- is

(a) Y^-, Z^-, X^- (b) Z^-, X^-, Y^-

(c) Y^-, X^-, Z^- (d) X^-, Z^-, Y^-

22. What is the minimum pH required to prevent the precipitation of ZnS in a solution that is 0.01 M $ZnCl_2$ and saturated with 0.10 M H_2S ?

(Given : $K_{sp} = 10^{-21}$, $K_{a_1} \times K_{a_2} = 10^{-20}$)

(a) 0 (b) 1 (c) 2 (d) 4

23. Which of the following is not a redox reaction?

(a) $CaCO_3 \longrightarrow CaO + CO_2$

(b) $Na + H_2O \longrightarrow NaOH + \frac{1}{2}H_2$

(c) $MnCl_3 \longrightarrow MnCl_2 + \frac{1}{2}Cl_2$

(d) $O_2 + 2H_2 \longrightarrow 2H_2O$

24. When a piece of copper wire is immersed in a solution of aqueous silver nitrate, the solution becomes blue. This is a consequence of

(a) oxidation of silver

(b) oxidation of copper

(c) formation of copper complex

(d) reduction of copper.

25. The pK_a of a weak acid (HA) is 4.5. The pOH of an aqueous buffered solution of HA in which 50% of the acid is ionized, is

(a) 4.5 (b) 2.5 (c) 9.5 (d) 7.0

NUMERICAL VALUE TYPE

26. If the solubility product of AB_2 is 3.20×10^{-11} M^3, then the solubility of AB_2 in pure water is ____ $\times 10^{-4}$ mol L^{-1}. [Assuming that neither kind of ion reacts with water]

27. 0.01 M AgBr is gradually added to a solution that has $[CrO_4^{2-}] = 0.010$ M and $[Br^-] = 0.010$ M. $[Br^-]$ remaining in the solution at the point where Ag_2CrO_4 starts precipitating is 3.33×10^{-x} M. The value of x is _____.

$K_{sp}(Ag_2CrO_4) = 2.25 \times 10^{-12}$, $K_{sp}(AgBr) = 5.0 \times 10^{-13}$

28. If the following is balanced reaction,

$4O_2^{x-} + 2H_2O \longrightarrow 4OH^- + 3O_2$, then x is _____.

29. Among the following, the number of underlined elements having +6 oxidation state is
$\underline{P}O_4^{3-}$, $H_2\underline{S}_2O_8$, $H_2\underline{S}O_5$, $\underline{O}F_2$, $\underline{Cr}_2O_7^{2-}$, $\underline{Cr}O_5$

30. What is the $[OH^-]$ in the final solution prepared by mixing 20.0 mL of 0.050 M HCl with 30.0 mL of 0.10 M $Ba(OH)_2$?

SOLUTIONS

1. (d): For the reaction, $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$

$E^\circ_{cell} = E^\circ_{Fe^{3+}/Fe^{2+}} - E^\circ_{I_2/I^-} = 0.77 - (0.54) = +0.23$ V

Here, E°_{cell} is +ve so, the reaction is feasible.

For the reaction,

$Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$

$E^\circ_{cell} = E^\circ_{Ag^+/Ag} - E^\circ_{Cu^{2+}/Cu} = 0.80 - (0.34) = +0.46$ V

Here, E°_{cell} is +ve so, the reaction is feasible.

For the reaction, $2Fe^{3+} + Cu \rightarrow 2Fe^{2+} + Cu^{2+}$

$E^\circ_{cell} = E^\circ_{Fe^{3+}/Fe^{2+}} - E^\circ_{Cu^{2+}/Cu} = 0.77 - (0.34) = +0.43$ V

Here, E°_{cell} is +ve so, the reaction is feasible.

For the reaction, $Ag + Fe^{3+} \rightarrow Ag^+ + Fe^{2+}$

$E^\circ_{cell} = E^\circ_{Fe^{3+}/Fe^{3+}} - E^\circ_{Ag^+/Ag} = 0.77 - (0.80) = -0.03$ V

Here, E°_{cell} is negative so, the reaction is not feasible.

2. (a): Solubility of $AB = \sqrt{K_{sp}} = 2\times10^{-10}$

Solubility of $A_2B = \sqrt[3]{\dfrac{K_{sp}}{4}} = 2\times10^{-4}$

Solubility of $AB_3 = \left[\dfrac{K_{sp}}{27}\right]^{1/4} = 10^{-8}$

3. (d): $2NH_3 \rightarrow N_2 + 6e^-$ or, $NH_3 \rightarrow 1/2\ N_2 + 3e^-$

$\therefore$ Eq. wt. $= M/3 = 17/3$

4. (d): The value of K_{eq} is the measure of extent of reaction. For most stable oxide, K_{eq} should be minimum.

5. (c): In CH_4, oxidation number of carbon is −4 while in CCl_4, oxidation number of carbon is +4. Thus, the change in oxidation number of carbon in the given reaction is from −4 to +4.

6. (c):

	$A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$		
Initial moles	2	4	0
Moles at eqm	$2-x$	$4-x$	$2x$

$$K_c = \frac{4x^2}{(2-x)(4-x)} = 4 \Rightarrow x = 1.33 \text{ mole}$$

$$[AB_{(g)}] = \frac{2\times1.33}{4} = 0.66\ M$$

7. (c): Here, Br_2 disproportionates (simultaneous oxidation and reduction), so its equivalent weight is the sum of equivalent weights of the half reactions.

$2e^- + Br_2 \longrightarrow 2Br^-$ $(x = 2)$ (reduction)

$Br_2 \longrightarrow 2BrO_3^- + 10e^-$ $(x = 10)$ (oxidation)

$$\therefore \quad \text{Eq. wt.} = \frac{M}{2} + \frac{M}{10}$$

8. (b): $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

$$Q_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Given, $[NH_3] = \dfrac{8.13}{20}\ M = 0.4065\ M;$

$$[N_2] = \frac{1.57}{20}\ M = 0.0785\ M$$

$$[H_2] = \frac{1.92}{20}\ M = 0.096\ M$$

$$Q_c = \frac{[0.4065\ M]^2}{[0.0785\ M][0.096\ M]^3} = 2.379\times10^3\ M^{-2}$$

$Q_c \neq K_c$, so the reaction is not in equilibrium. $Q_c > K_c$, it indicates that the reaction will proceed in the direction of reactants.

9. (b): $K_p = \dfrac{p^2_{HI}}{p_{H_2} \times p_{I_2}}$

When I_2 is added at equilibrium, the reaction moves in a direction where its concentration is reduced, *i.e.*, in the forward direction (Le-Chatelier's Principle). Thus, concentration of HI increases whereas that of H_2 decreases. When I_2 is added initially its concentration increases, but gradually it decreases as the reaction proceeds.

10. (b)

11. (c): $d = \dfrac{PM}{RT}$

$$\text{or} \quad M = \frac{dRT}{P} = \frac{0.925\times0.0821\times900}{1}$$

i.e., Molecular mass of mixture (M_{mix}) = 68.35 g/mol

Normal molecular mass of $SO_3(M)$ = 80 g/mol

	SO_3	$\rightleftharpoons$ SO_2	+ 1/2 O_2
Initial moles:	1	0	0
Moles at eqm.:	$1-\alpha$	α	$\alpha/2$

$$\text{Total no. of moles at eqm.} = 1 + \frac{\alpha}{2}$$

If volume of one mole of vapour = V

Volume of $\left(1+\frac{\alpha}{2}\right)$ mole of vapour $=\left(1+\frac{\alpha}{2}\right)V$

$d \propto \frac{1}{V}$ and molecular mass = 2 × V.D.

$\therefore \quad \text{Mol. mass} \propto \frac{1}{V}$

$$\therefore \quad \frac{\text{Observed mol. mass}}{\text{Normal mol. mass}} = \frac{1}{1+\frac{\alpha}{2}}$$

$$\text{or} \quad \frac{68.35}{80} = \frac{1}{1+\frac{\alpha}{2}} \quad \text{or} \quad 1+\frac{\alpha}{2} = \frac{80}{68.35}$$

or $\alpha = 0.34$ or 34%

12. (b): $\overset{+7}{MnO_4^-} + 5e^- \longrightarrow Mn^{2+}$

Since 1 mole of MnO_4^- accepts 5 moles of electrons, therefore, 5 moles of electrons are lost by 2.5 moles of M^{x+}.

$\therefore$ 1 mole of M^{x+} will lose electrons = 5/2.5 = 2 moles

Since, M^{x+} changes to MO_3^- (where O.N. of M = +5) by donating 2 electrons.

$\therefore$ Oxidation state of M *i.e.* $x = +5 - 2 = +3$

13. (b): pH of the saturated solution of $Ca(OH)_2$ = 9

$\therefore$ pOH of the saturated solution of $Ca(OH)_2$ = 5

$\Rightarrow \quad [OH^-] = 10^{-5}$ ($\because$ pH + pOH = 14).

$$Ca(OH)_2 \rightleftharpoons \underset{s}{Ca^{2+}} + \underset{2s}{2OH^-}$$

$$\underset{1/2\times10^{-5}}{} \qquad \underset{10^{-5}}{}$$

$K_{sp} = [Ca^{2+}]\,[OH^-]^2 = [1/2\times10^{-5}]\,[10^{-5}]^2 = 0.5\times10^{-15}$

14. (c): Moles of NaOH required for 1 L solution = x

$\therefore$ Moles of NaOH required for 100 mL of solution = 0.1 x

Now, $0.1x = 1 \times V \Rightarrow V = 0.1\,x$ L = 100 x mL

15. (b): $(NH_4)_2S$ = 0.021 M;

$[S^{2-}]$ = 0.021 M

At equilibrium, $[Zn^{2+}][S^{2-}] = K_{sp}$ of ZnS

$$[Zn^{2+}] = \frac{4.51\times10^{-24}}{0.021} = 2.15\times10^{-22}\,\text{M}$$

$[Zn^{2+}]$ left in solution = $2.15 \times 10^{-22} \times 65$ g/litre

$$= \frac{2.15\times10^{-22}\times65\times12}{1000}\,\text{g in 12 mL}$$

$= 1.677 \times 10^{-22}$ g in 12 mL

16. (d): For the reaction, $S_{(s)} + O_{2(g)} \rightleftharpoons SO_{2(g)}$

$$K_1 = \frac{[SO_2]}{[O_2]} = 10^{52}$$

Then for the reaction, $2SO_{2(g)} \rightleftharpoons 2S_{(s)} + 2O_{2(g)}$

$$K_1' = \frac{[O_2]^2}{[SO_2]^2} = \left(\frac{1}{10^{52}}\right)^2 \qquad \text{...(i)}$$

For the reaction, $2S_{(s)} + 3O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

$$K_2 = \frac{[SO_3]^2}{[O_2]^3} = 10^{129} \qquad \text{...(ii)}$$

For the reaction, $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

$$K_3 = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

By multiplying equation (i) and (ii), we get

$$K_3 = K'_1 \times K_2 = \left(\frac{1}{10^{52}}\right)^2 \times 10^{129} = \frac{10^{129}}{10^{104}} = 10^{25}$$

17. (c) **18. (c)**

19. (d): $pH_1 = pK_a + \log\left(\frac{\text{Salt}}{\text{Acid}}\right)$

$$pH_1 = pK_a + \log\left(\frac{x_1}{y_1}\right),\ pH_2 = pK_a + \log\left(\frac{x_2}{y_2}\right)$$

$$pH_2 - pH_1 = \log\frac{x_2}{y_2} - \log\frac{x_1}{y_1}$$

$$2 = \log\left(\frac{x_2/y_2}{x_1/y_1}\right) \quad \therefore \quad \frac{x_2/y_2}{x_1/y_1} = 10^2 = 100$$

This is only possible, if the concentration of salt is increased by 10 times and the concentration of acid is decreased by 10 times.

20. (d): Adding given equations, we get

$A_2 + 3B_2 \longrightarrow 2D_2$, $K = 4 \times 16 = 64$

(P) Dividing by 2, $\frac{1}{2}A_2 + \frac{3}{2}B_2 \longrightarrow D_2$, $K = \sqrt{64} = 8$

(Q) Reversing, $2D_2 \longrightarrow A_2 + 3B_2$, $K = 1/64$

(R) $A_2 + 3B_2 \longrightarrow 2D_2$, $K = 64$

(S) Reversing and dividing by 2,

$$D_2 \longrightarrow B_2 + \frac{1}{2}C,\ K = \frac{1}{4}$$

21. (a): Since AX does not react with any of the solutions, it means that X is least easily oxidized.

Since AY reacts with both X_2 and Z_2, *i.e.*,

$2Y^- + X_2 \rightarrow 2X^- + Y_2$ and $2Y^- + Z_2 \rightarrow 2Z^- + Y_2$, therefore, Y^- is most easily oxidized.

Since AZ reacts with only X_2, *i.e.*,

$2Z^- + X_2 \rightarrow 2X^- + Z_2$, therefore, Z^- is more easily oxidized than X^-. Combining all the results, the decreasing order of oxidation of anions follows the order $Y^- > Z^- > X^-$

22. (b) : $K_{sp} = [Zn^{2+}][S^{2-}]$

$$[S^{2-}] = \frac{10^{-21}}{0.01} = 10^{-19}$$

$$H_2S \rightleftharpoons H^+ + HS^- \; ; \; K_{a_1} = \frac{[H^+][HS^-]}{[H_2S]}$$

$$HS^- \rightleftharpoons H^+ + S^{2-} \; ; \; K_{a_2} = \frac{[H^+][S^{2-}]}{[HS^-]}$$

$$K_{a_1} \cdot K_{a_2} = \frac{[H^+]^2[S^{2-}]}{[H_2S]}$$

$$10^{-20} = \frac{[H^+]^2 \times 10^{-19}}{0.1} \Rightarrow [H^+] = 0.1 \text{ or } pH = 1$$

23. (a) : In redox reaction, oxidation and reduction takes place simultaneously.

$$\overset{+2+4-2}{CaCO_3} \longrightarrow \overset{+2-2}{CaO} + \overset{+4-2}{CO_2}$$

Since, in this reaction, no oxidation or reduction takes place thus, it is not a redox reaction.

24. (b) : Solution turns blue due to oxidation of Cu to Cu^{2+} ions in the solution.

$$Cu + 2AgNO_3 \longrightarrow Cu(NO_3)_2 + 2Ag$$

25. (c) : For buffer solution

$$pH = pK_a + \log\left[\frac{Salt}{Acid}\right] = 4.5 + \log\left[\frac{Salt}{Acid}\right]$$

As H*A* is 50% ionized, hence [Salt] = [Acid]

$pH = 4.5 \Rightarrow pOH = 14 - 4.5 = 9.5$

26. (2) : $AB_{2(s)} \rightleftharpoons \underset{S}{A^{2+}_{(aq)}} + \underset{2S}{2B^-_{(aq)}}$

$K_{sp} = (S)(2S)^2$

$3.20 \times 10^{-11} = 4S^3$ or $S = 2 \times 10^{-4}$ mol L^{-1}

27. (8) : Calculate $[Ag^+]$, needed separately to precipitate CrO_4^{2-} and Br^- as Ag_2CrO_4 and AgBr respectively. Smaller the value of $[Ag^+]$, earlier the precipitation of that species. Using $[Ag^+]$ required to precipitate the ion at later stage, concentration of the ion earlier precipitated can be calculated.

For precipitation of Ag_2CrO_4, $[Ag^+]^2[CrO_4^{2-}] > K_{sp}$

$$[Ag^+]_{min} = \left(\frac{K_{sp}(Ag_2CrO_4)}{[CrO_4^{2-}]}\right)^{\frac{1}{2}} = \left(\frac{2.25\times10^{-12}}{0.010}\right)^{\frac{1}{2}}$$

$$= 1.50 \times 10^{-5} \text{ M}$$

For the precipitation of AgBr, $[Ag^+][Br^-] > K_{sp}$

$$[Ag^+]_{min} = \frac{K_{sp}(AgBr)}{[Br^-]} = \frac{5.0\times10^{-13}}{0.010} = 5.0\times10^{-11}\text{M}$$

$[Ag^+]$ required for precipitation of AgBr is less than that required for precipitation of Ag_2CrO_4. Hence, AgBr precipitates earlier than Ag_2CrO_4.

$[Ag^+]$ when Ag_2CrO_4 starts precipitating

$$= 1.50 \times 10^{-5} \text{ M}$$

$[Br^-]$ remaining at this stage

$$= \frac{K_{sp}(AgBr)}{[Ag^+]} = \frac{5.0\times10^{-13}}{1.5\times10^{-5}} = 3.33\times10^{-8}\text{M}$$

28. (1) : $4O_2^- + 2H_2O \longrightarrow 4OH^- + 3O_2$

29. (4) :

P in PO_4^{3-}	+5
S in $H_2S_2O_8$	+6
S in H_2SO_5	+6
O in OF_2	+2
Cr in $Cr_2O_7^{2-}$	+6
Cr in CrO_5	+6

30. (0.10) : Millimoles of H^+ produced = $20 \times 0.05 = 1$

Millimoles of OH^- produced = $30 \times 0.1 \times 2 = 6$

($\because$ Each $Ba(OH)_2$ gives $2OH^-$.)

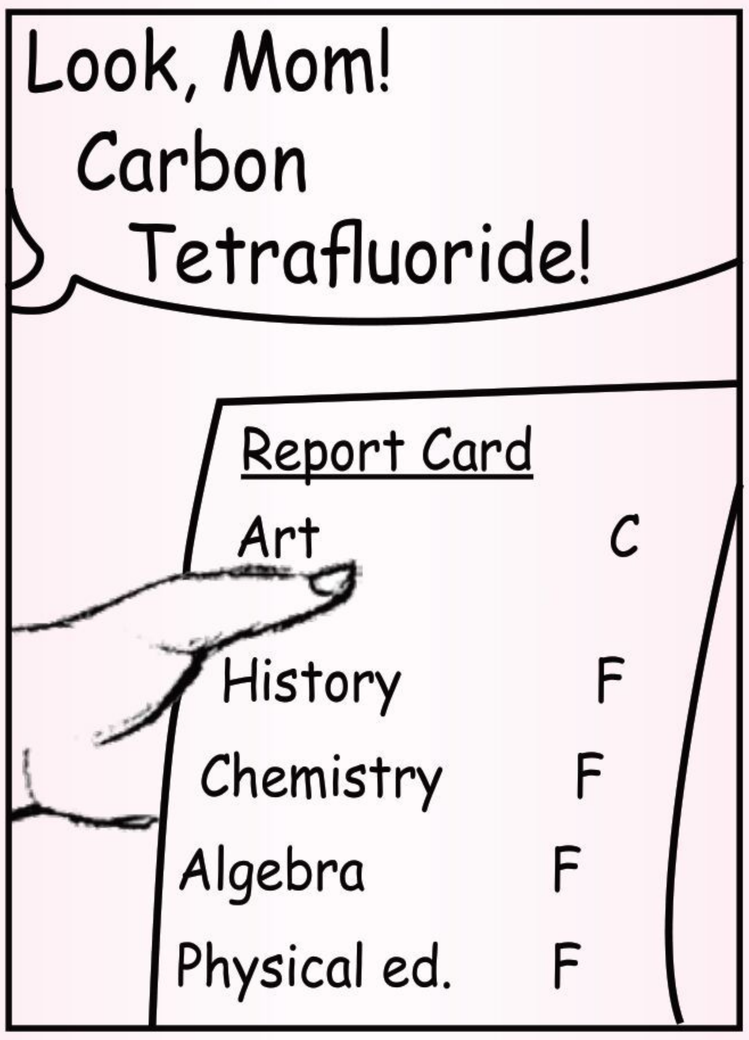
$\therefore$ Millimoles of OH^- remaining in solution

$= 6 - 1 = 5$

Total volume of solution = 20 + 30 = 50 mL

$$\therefore \quad [OH^-] = \frac{5}{50} = 0.1\text{ M}$$

COMIC CAPSULE



CBSE warm-up!

CLASS-XI

TERM-I OBJECTIVE TYPE QUESTIONS*

Practice Paper 2021

Time allowed : 90 minutes
Maximum marks : 35

GENERAL INSTRUCTIONS

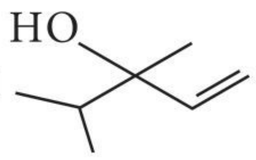
1. *The Question Paper contains three sections.*
2. *Section A has 25 questions. Attempt any 20 questions.*
3. *Section B has 24 questions. Attempt any 20 questions.*
4. *Section C has 6 questions. Attempt any 5 questions.*
5. *All questions carry equal marks.*
6. *There is no negative marking.*

- **Some Basic Concepts of Chemistry**
- **Structure of Atom**
- **Classification of Elements and Periodicity in Properties**
- **Chemical Bonding and Molecular Structure**
- **Redox Reactions**
- **Hydrogen**
- **Organic Chemistry : Some Basic Principles and Techniques**

SECTION - A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, ONLY first 20 will be considered for evaluation.

1. Calculate the longest wavelength (in Å) which can remove the electron from first Bohr's orbit.
(Given : $E_1 = 13.6$ eV)
(a) 303.81 (b) 912.24
(c) 1095.12 (d) 1215.67

2. The IUPAC name of the compound  is
(a) 3,4-dimethyl-1-penten-3-ol
(b) isopropyl–3–methylvinylcarbinol
(c) 2,3-dimethyl-4-penten-3-ol
(d) none of the above.

3. Suppose two elements X and Y combine to form two compounds XY_2 and X_2Y_3. 0.05 mole of XY_2 weigh 5 g while 3.011×10^{23} molecules of X_2Y_3 weigh 85 g. The atomic masses of X and Y are respectively
(a) 20, 30 (b) 30, 40
(c) 40, 30 (d) 80, 60

4. Few examples of the compounds formed by chemical bonding are given below. Mark the incorrect example.
(a) A molecule with central atom devoid of octet – BF_3
(b) A molecule with linear shape – CO_2
(c) A non-polar covalent compound between two different atoms – CH_4
(d) A molecule which is V-shaped with a bond angle 104.5° – NH_3

5. Carbon hydrides of the type, C_nH_{2n+2} do not act as Lewis acid or Lewis base. They behave as normal covalent hydrides because
(a) carbon hydrides are electron-rich hydrides
(b) carbon hydrides are electron-deficient hydrides
(c) carbon hydrides are electron-precise hydrides
(d) carbon hydrides are non-stoichiometric hydrides.

6. Hyperconjugation is most useful for stabilising which of the following carbocations?
(a) Neopentyl (b) *tert*-Butyl
(c) Isopropyl (d) Ethyl

***Practice paper for CBSE Exam Term- I as per the pattern issued by CBSE.**

7. A ball of mass 200 g is moving with a velocity of 10 m sec^{-1}. If the error in measurement of velocity is 0.1%, the uncertainty in its position is
(a) 3.32×10^{-31} m (b) 3.34×10^{-27} m
(c) 5.32×10^{-25} m (d) 2.64×10^{-32} m

8. In which of the following, the order is not in accordance with the property mentioned ?
(a) Li < Na < K < Rb – Atomic radius
(b) F > N > O > C – Ionisation enthalpy
(c) Si < P < S < Cl – Electronegativity
(d) F < Cl < Br < I – Electronegativity

9. The less reactivity of chlorine atom in, $CH_2 = CH—Cl$ is due to
(a) inductive effect
(b) resonance stabilisation
(c) electromeric effect (d) electronegativity.

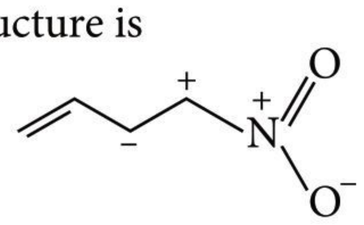
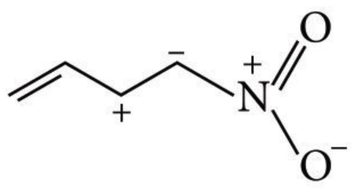
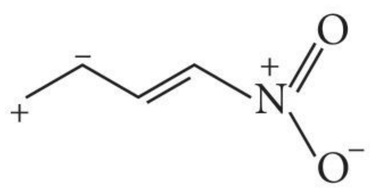
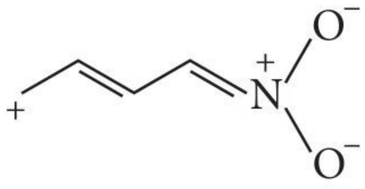
10. Which of the following statement is not correct from the molecular orbital theory?
(a) Be_2 is not a stable molecule.
(b) He_2 is not stable but He_2^+ is expected to exist.
(c) Bond strength of N_2 is maximum amongst the homonuclear diatomic molecules belonging to the second period.
(d) The order of energies of molecular orbitals in N_2 molecule is,
$\sigma 2s < \sigma^* 2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$

11. Consider the following reaction : $HCHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow 2Ag + HCOO^- + 4NH_3 + 2H_2O$
Which of the following statements regarding oxidation and reduction is correct?
(a) HCHO is oxidised to $HCOO^-$ and $[Ag(NH_3)_2]^+$ is reduced to Ag.
(b) HCHO is reduced to $HCOO^-$ and $[Ag(NH_3)_2]^+$ is oxidised to Ag.
(c) $[Ag(NH_3)_2]^+$ is reduced to Ag while OH^- is oxidised to $HCOO^-$.
(d) $[Ag(NH_3)_2]^+$ is oxidised to NH_3 while HCHO is reduced to H_2O.

12. In a reaction container, 100 g hydrogen and 100 g Cl_2 are mixed for the formation of HCl gas. What is the limiting reagent and how much HCl is formed in the reaction?
(a) H_2 is limiting reagent and 36.5 g of HCl are formed.
(b) Cl_2 is limiting reagent and 102.8 g of HCl are formed.
(c) H_2 is limiting reagent and 142 g of HCl are formed.
(d) Cl_2 is limiting reagent and 73 g of HCl are formed.

13. Which one of the following carbanions is least stable?
(a) $CH_3CH_2^-$ (b) $(C_6H_5)_3C^-$
(c) CH_3^- (d) $(CH_3)_3C^-$

14. Calculate the wavelength for the shortest wavelength transition in the Balmer series of atomic hydrogen.
(a) 27419.25 cm^{-1} (b) 2314.59 cm^{-1}
(c) 109677 cm^{-1} (d) 54838.5 cm^{-1}

15. Among the following, the least stable resonance structure is
(a) 
(b) 
(c) 
(d) 

16. What is the hybrid state of carbon in ethyne, graphite and diamond?
(a) sp^2, sp, sp^3 (b) sp, sp^2, sp^3
(c) sp^3, sp^2, sp (d) sp^2, sp^3, sp

17. Study the following reactions and mark the correct properties shown by water.
(i) $SO_3 + H_2O \rightarrow H_2SO_4$
(ii) $Cl_2O_7 + H_2O \rightarrow 2HClO_4$
(iii) $CaO + H_2O \rightarrow Ca(OH)_2$
(iv) $Na_2O + H_2O \rightarrow 2NaOH$
(a) All oxides react with water to give hydroxides.
(b) Acidic oxides are formed by metals and basic oxides by non-metals.
(c) Non-metal oxides combine with water to form acids while metallic oxides combine with water to form alkalies.
(d) Acidic oxides are stronger than basic oxides since they form strong acids.

18. In the given reaction,
$2H_2O_{2(l)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$
100 mL of '*X*' molar H_2O_2 gives 3 L of $O_{2(g)}$ under the condition when 1 mole occupies 24 L. The value of '*X*' is
(a) 2.5 (b) 1.0 (c) 0.5 (d) 0.25

19. As we move from left to right, the electronegativity increases. An atom which is highly electronegative has
(a) large size
(b) low electron affinity
(c) high ionisation enthalpy
(d) low chemical reactivity.

20. Homolytic fission of a covalent bond leads to the formation of

(a) nucleophile (b) free radical

(c) carbocation (d) carbanion.

21. Which of the following configurations does not follow Hund's rule of maximum multiplicity?

(a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$

(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4\ 4s^2$

22. Arrange the following in increasing order of covalent character – NaCl, $MgCl_2$, $AlCl_3$.

(a) $NaCl < MgCl_2 < AlCl_3$

(b) $MgCl_2 < NaCl < AlCl_3$

(c) $AlCl_3 < MgCl_2 < NaCl$

(d) $NaCl < AlCl_3 < MgCl_2$

23. Two elements '*P*' and '*Q*' combine to form a compound. Atomic mass of '*P*' is 12 and '*Q*' is 16. Percentage of '*P*' in the compound is 27.3. What will be the empirical formula of the compound?

(a) P_2Q_2 (b) PQ (c) P_2Q (d) PQ_2

24. Which of the following pairs are isostructural ?

(a) SO_4^{2-} and BF_4^- (b) NH_3 and NH_4^+

(c) CO_3^{2-} and CO_2 (d) CH_4 and BF_3

25. First and second ionisation enthalpies (in kJ/mol) of few elements are given.

Element	IE_1	IE_2
(i)	520	7300
(ii)	900	1760
(iii)	1680	3380
(iv)	2080	3963

Which of the above elements will form halides with formula MX_2?

(a) (i) and (ii) (b) (i) and (iii)

(c) (ii) and (iii) (d) (i) and (iv)

SECTION - B

This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, ONLY first 20 will be considered for evaluation.

26. What will be the balanced equation in acidic medium for the given reaction?

$Cr_2O_{7(aq)}^{2-} + SO_{2(g)} \rightarrow Cr_{(aq)}^{3+} + SO_{4(aq)}^{2-}$

(a) $Cr_2O_{7(aq)}^{2-} + 3SO_{2(g)} + 2H_{(aq)}^{+} \rightarrow 2Cr_{(aq)}^{3+} + 3SO_{4(aq)}^{2-} + H_2O_{(l)}$

(b) $2Cr_2O_{7(aq)}^{2-} + 3SO_{2(g)} + 4H_{(aq)}^{+} \rightarrow 4Cr_{(aq)}^{3+} + 3SO_{4(aq)}^{2-} + 2H_2O_{(l)}$

(c) $Cr_2O_{7(aq)}^{2-} + 3SO_{2(g)} + 14H_{(aq)}^{+} \rightarrow 2Cr_{(aq)}^{3+} + 3SO_{4(aq)}^{2-} + 7H_2O_{(l)}$

(d) $Cr_2O_{7(aq)}^{2-} + 6SO_{2(g)} + 7H_{(aq)}^{+} \rightarrow 2Cr_{(aq)}^{3+} + 6SO_{4(aq)}^{2-} + 7H_2O_{(l)}$

27. The limiting line in Balmer series will have a frequency of

(a) $6.22 \times 10^{15} s^{-1}$ (b) $7.22 \times 10^{14} s^{-1}$

(c) $8.22 \times 10^{14} s^{-1}$ (d) $9.22 \times 10^{14} s^{-1}$

28. Which of the following is a non-benzenoid aromatic compound?

(a) Benzoic acid (b) Naphthalene

(c) Tropolone (d) Anthracene

29. 0.24 g of a volatile substance displaced 53.78 mL of air at STP. The molecular weight of the substance is

(a) 24 g (b) 53.78 g

(c) 50 g (d) 100 g

30. The molecules like BrF_5 and $XeOF_4$ are square pyramidal in shape. What is the type of hybridisation shown in these molecules?

(a) dsp^3 (b) dsp^2

(c) sp^3d (d) sp^3d^2

31. The isotopes of hydrogen have different physical properties due to difference in mass. They have almost same chemical properties with a difference in their rates of reactions which is mainly due to

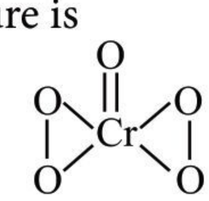
(a) their different enthalpy of bond dissociation

(b) different electronic configurations

(c) different atomic masses

(d) different physical properties.

32. The oxidation number of Cr in CrO_5 which has the following structure is



(a) +4 (b) +5 (c) +6 (d) +3

33. The energy of second Bohr's orbit of hydrogen atom is –328 kJ mol^{-1}. The energy of the third Bohr's orbit of He^+ is

(a) –583.11 kJ mol^{-1} (b) –853.11 kJ mol^{-1}

(c) –145.78 kJ mol^{-1} (d) –511.83 kJ mol^{-1}

34. The conditions for the combination of atomic orbitals to form molecular orbitals are stated below. Mark the incorrect condition mentioned here.

(a) The combining atomic orbitals must have nearly same energy.

(b) The combining atomic orbitals must overlap to maximum extent.

(c) Combining atomic orbitals must have same symmetry about the molecular axis.

(d) Pi (π) molecular orbitals are symmetrical around the bond axis.

35. Which of the following statements regarding the variation of atomic radii in the periodic table is not true?

(a) In a group, there is continuous increase in size with increase in atomic number.

(b) In 4*f*-series, there is a continuous decrease in size with increase in atomic number.

(c) The size of inert gases is larger than halogens.

(d) In 3rd period, the size of atoms increases with increase in atomic number.

36. The oxidation state of sulphur in the anions SO_3^{2-}, SO_4^{2-}, $S_2O_4^{2-}$, $S_2O_6^{2-}$ is in the order of

(a) $S_2O_4^{2-} > S_2O_6^{2-} > SO_4^{2-} > SO_3^{2-}$

(b) $S_2O_6^{2-} > SO_3^{2-} > S_2O_4^{2-} > SO_4^{2-}$

(c) $SO_4^{2-} > S_2O_6^{2-} > SO_3^{2-} > S_2O_4^{2-}$

(d) $SO_3^{2-} > SO_4^{2-} > S_2O_4^{2-} > S_2O_6^{2-}$

37. Match the column I with column II and mark the appropriate choice.

Column I		Column II	
(A)	Mass of H_2 produced when 0.5 mole of zinc reacts with excess of HCl	(i)	3.01×10^{23} molecules
(B)	Mass of all atoms of a compound with formula $C_{70}H_{22}$	(ii)	6.023×10^{23} molecules
(C)	Number of molecules in 35.5 g of Cl_2	(iii)	1.43×10^{-21} g
(D)	Number of molecules in 64 g of SO_2	(iv)	1 g

(a) (A) → (ii), (B) → (i), (C) → (iv), (D) → (iii)

(b) (A) → (i), (B) → (ii), (C) → (iii), (D) → (iv)

(c) (A) → (iv), (B) → (iii), (C) → (i), (D) → (ii)

(d) (A) → (iv), (B) → (iii), (C) → (ii), (D) → (i)

38. In which of the following molecules octet rule is not followed?

(a) NH_3 (b) CH_4

(c) CO_2 (d) NO

39. Which compound is formed when calcium carbide reacts with heavy water?

(a) C_2D_2 (b) CaD_2

(c) CD_2 (d) Ca_2D_2

40. Match the reactions given in column I with the type of reactions given in column II and mark the appropriate choice.

Column I		Column II	
(A)	$CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$	(i)	Addition reaction
(B)	$CH_2 = CH_2 + Br_2 \rightarrow CH_2Br - CH_2Br$	(ii)	Rearrangement reaction
(C)	$CH_3CH_2OH \xrightarrow[300°C]{Cu} CH_3CHO$	(iii)	Substitution reaction
(D)	$NH_4CNO \xrightarrow{Heat} NH_2 - CO - NH_2$	(iv)	Elimination reaction

(a) (A) → (i), (B) → (ii), (C) → (iii), (D) → (iv)

(b) (A) → (iii), (B) → (i), (C) → (iv), (D) → (ii)

(c) (A) → (ii), (B) → (iv), (C) → (i), (D) → (iii)

(d) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)

41. What are the possible values of n, l and m_l for an atomic orbital 4*f*?

(a) $n = 4$, $l = 0, 1, 2, 3$, $m_l = -2, -1, 0, +1, +2$

(b) $n = 4$, $l = 3$, $m_l = -3, -2, -1, 0, +1, +2, +3$

(c) $n = 4$, $l = 2$, $m_l = -2, -1, 0, +1, +2, +3$

(d) $n = 4$, $l = 0, 1$, $m_l = -1, 0, +1$

42. The electronic configuration of few elements is given below. Mark the statement which is not correct about these elements.

(i) $1s^2\ 2s^2\ 2p^6\ 3s^1$ (ii) $1s^2\ 2s^2\ 2p^5$

(iii) $1s^2\ 2s^2\ 2p^6$ (iv) $1s^2\ 2s^2\ 2p^3$

(a) (i) is an alkali metal.

(b) (iii) is a noble metal.

(c) (i) and (ii) form ionic compounds.

(d) (iv) has high ionisation enthalpy.

43. Match the column I with column II and mark the appropriate choice.

18+

WHAT IS AVAXHOME?

AVAXHOME-

the biggest Internet portal, providing you various content: brand new books, trending movies, fresh magazines, hot games, recent software, latest music releases.

Unlimited satisfaction one low price
Cheap constant access to piping hot media
Protect your downloadings from Big brother
Safer, than torrent-trackers

18 years of seamless operation and our users' satisfaction

All languages
Brand new content
One site

AVXLIVE.ICU

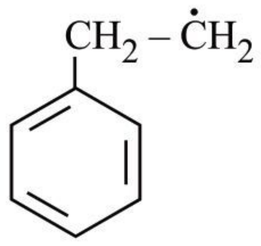
AvaxHome - Your End Place

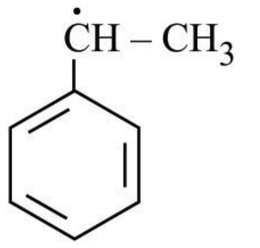
We have everything for all of your needs. Just open https://avxlive.icu

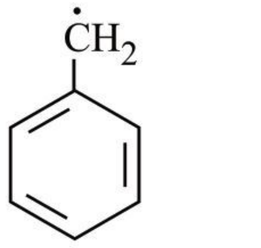
Column I		Column II	
(A)	C_2H_2	(i)	sp^3d^2 hybridisation
(B)	SF_6	(ii)	sp^3d^3 hybridisation
(C)	SO_2	(iii)	sp hybridisation
(D)	IF_7	(iv)	sp^2 hybridisation

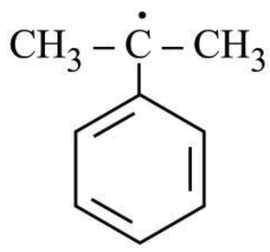
(a) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)
(b) (A) → (iii), (B) → (i), (C) → (iv), (D) → (ii)
(c) (A) → (ii), (B) → (iii), (C) → (i), (D) → (iv)
(d) (A) → (iv), (B) → (i), (C) → (iii), (D) → (ii)

44. The most stable free radical among the following is

(a) 

(b) 

(c) 

(d) 

45. **Given below are two statements labelled as Assertion (A) and Reason (R).**
Assertion : Melting and boiling points of D_2O are higher than those of ordinary H_2O.
Reason : D_2O has lesser degree of association than H_2O and lower molecular mass, hence higher melting and boiling points.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

46. **Given below are two statements labelled as Assertion (A) and Reason (R).**
Assertion : The order of reactivity of carbocation is $2° > 3° > 1°$.
Reason : Carbon atom in carbonium ion is in sp^3 state of hybridisation.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

47. **Given below are two statements labelled as Assertion (A) and Reason (R).**
Assertion : Boiling point of *p*-nitrophenol is greater than that of *o*-nitrophenol.
Reason : There is intramolecular hydrogen bonding in *p*-nitrophenol and intermolecular hydrogen bonding in *o*-nitrophenol.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

48. **Given below are two statements labelled as Assertion (A) and Reason (R).**
Assertion : HNO_3 acts only as oxidising agent while HNO_2 can act both as a reducing agent and an oxidising agent.
Reason : In HNO_3, oxidation state of nitrogen is +5 which is maximum. In HNO_2, oxidation state of nitrogen is +3 which can change from –3 to +5.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

49. **Given below are two statements labelled as Assertion (A) and Reason (R).**
Assertion : H_2 remains unreactive at room temperature.
Reason : H – H Bond dissociation enthalpy is very high.
Select the most appropriate answer from the options given below :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

CONCEPT MAP

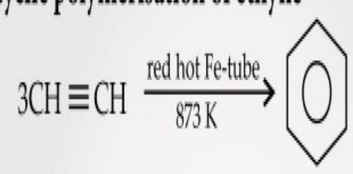
AROMATIC COMPOUNDS

Benzenoids

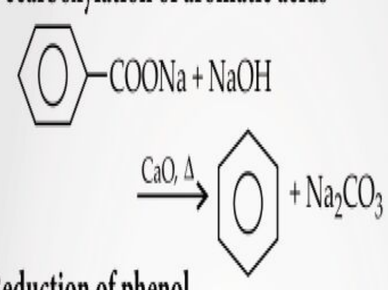
Aromatic hydrocarbons containing a benzene ring are called benzenoids. Their general formula is C_nH_{2n-6m}, (where, n = no. of C-atoms, m = no. of rings.)

Preparation

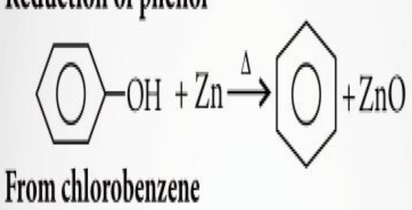
Cyclic polymerisation of ethyne



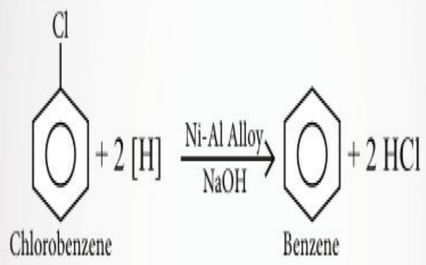
Decarboxylation of aromatic acids

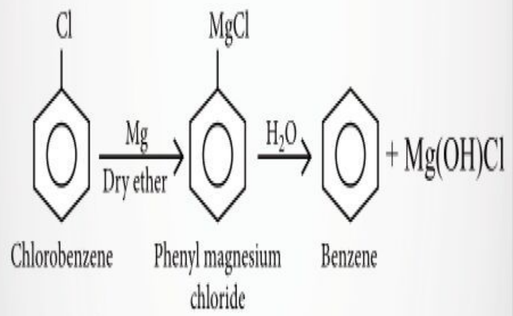


Reduction of phenol

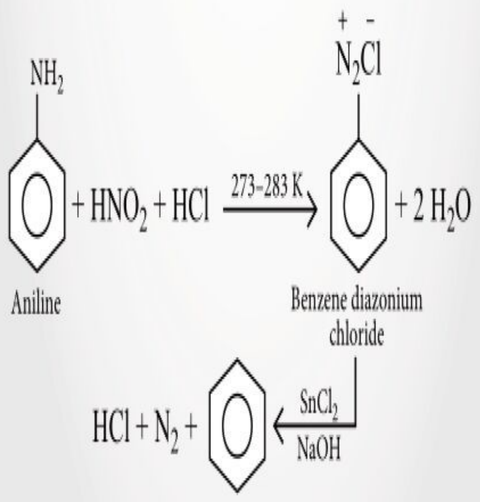


From chlorobenzene

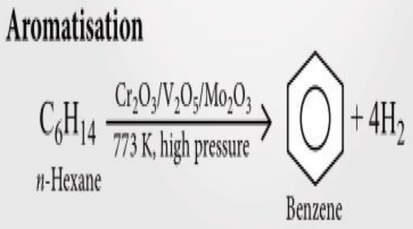




From aniline



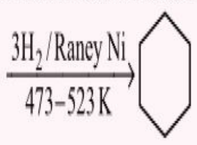
Aromatisation

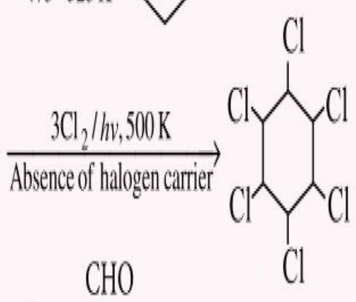


Properties

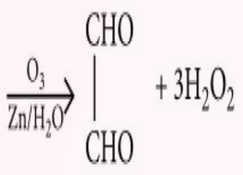
B

Addition reactions



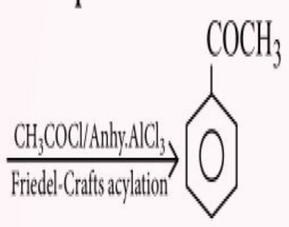


E

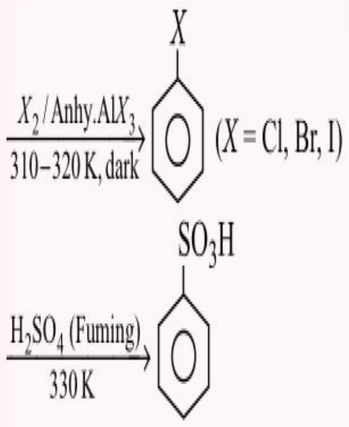


Electrophilic substitution reactions

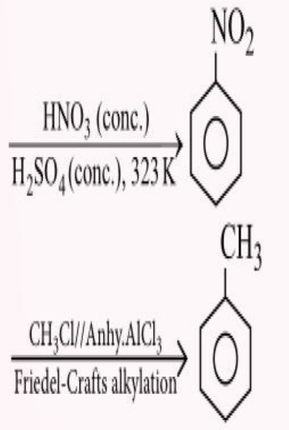
N



Z

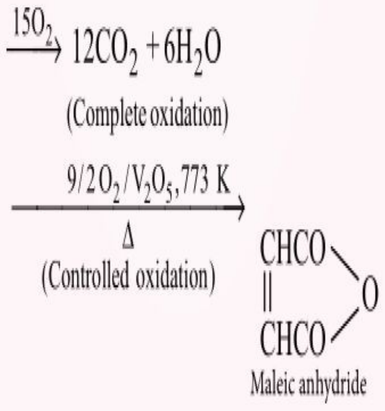


E



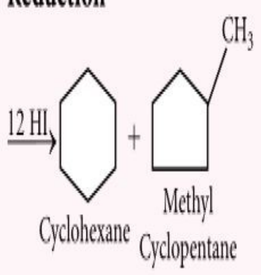
Oxidation reactions

N

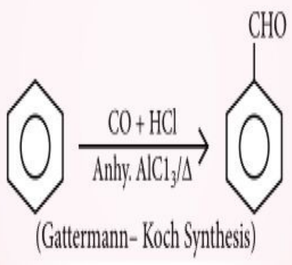


Reduction

E



Formylation



(Gattermann- Koch Synthesis)

AROMATIC COMPOUNDS

- Planar, cyclic and completely conjugated
- Contains $(4n + 2)$ π-electrons, (Huckel's Rule) (where, n = an integer)
- If, on ring closure, the π-electron energy of an open chain polyene decreases

e.g., [6] annulene (Benzene)

Anti-aromatic Compounds

- Planar, cyclic and completely conjugated
- Contains $4n$ π-electrons, (where, n = an integer)
- If, on ring closure, the π-electron energy increases

e.g., cyclopentadienyl cation

Non-aromatic Compounds

- Non-planar, non-cyclic and not completely conjugated
- If, on ring closure, the π-electron energy remains the same

e.g., Alkanes, alkenes and 1, 3, 5-cycloheptatriene

Non-Benzenoids

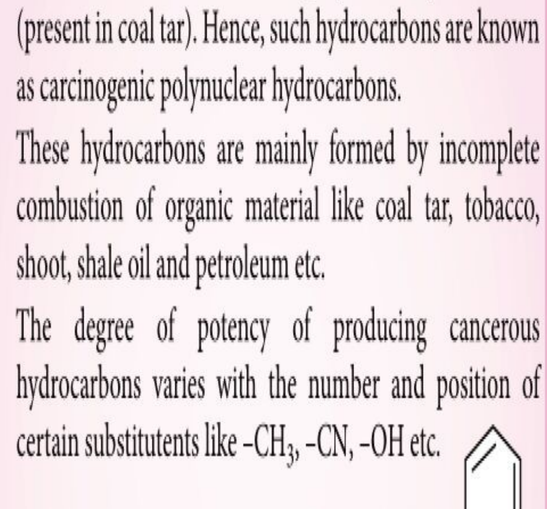
- Do not contain benzene ring

e.g., Azulene, tropolone, pyrrole, etc.

Polynuclear Hydrocarbons

Compounds having more than one aromatic ring are known as polynuclear hydrocarbons.

e.g.,

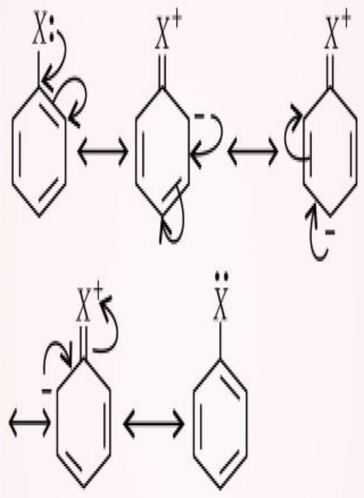


Directive Influence of Substituents

The ability of a group already present in the benzene ring to direct the incoming group to a particular position is called the directive influence of groups.

o, p-directive

Groups with positive mesomeric effect ($+M$) increases electron density at *o*-and *p*-positions due to delocalisation.

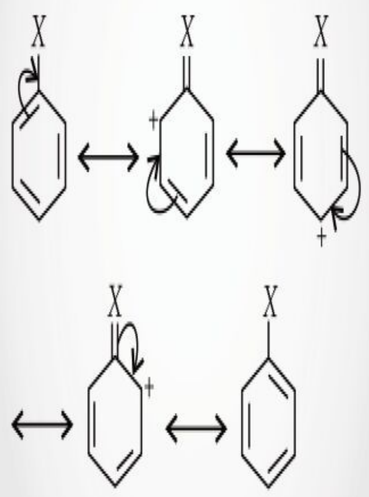


(Here, X may be $-CH_3$, $-C_2H_5$, $-OCH_3$, $-NH_2$, $-NHR$, $NHCOCH_3$, $-OH$, $-F$, $-Cl$, $-Br$, $-I$.)

Thus, electrophile attacks on *o*- and *p*-positions because these are electron rich positions.

m-directive

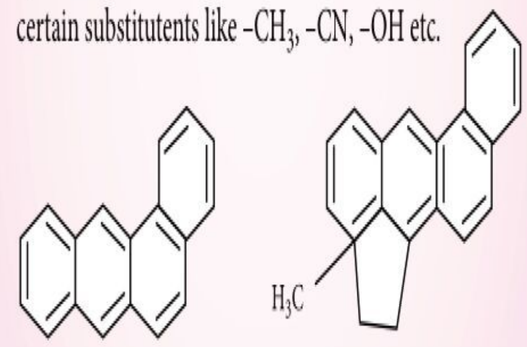
Groups with negative mesomeric effect ($-M$) decreases electron density on *o*- and *p*-positions, so electrophile will attack on *m*-position.



(Here, X may be $-NO_2$, $-CHO$, $-COR$, $-COOH$, $-COOR$, $-SO_3H$, $-CN$.)

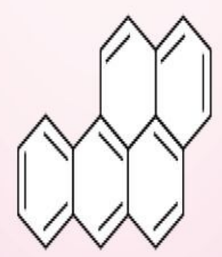
Carcinogenicity & Toxicity

- Radiations, chemicals and physical irritations, coal tar, hormones and certain viruses can be the cause of cancer. The most common out of these is polynuclear hydrocarbons (present in coal tar). Hence, such hydrocarbons are known as carcinogenic polynuclear hydrocarbons.
- These hydrocarbons are mainly formed by incomplete combustion of organic material like coal tar, tobacco, shoot, shale oil and petroleum etc.
- The degree of potency of producing cancerous hydrocarbons varies with the number and position of certain substitutents like $-CH_3$, $-CN$, $-OH$ etc.



1, 2-Benzanthracene

3-Methylcholanthrene



1, 2 - Benzpyrene

SECTION - C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, ONLY first 5 will be considered for evaluation.

50. If the radius of first orbit of H-atom is a_0, then de-Broglie wavelength of electron in 4^{th} orbit is

(a) $2\pi a_0$ (b) $16a_0$ (c) $a_0/4$ (d) $8\pi a_0$

51. According to VSEPR theory,

(a) the shape of the molecule depends upon the bonded electron pairs

(b) pair of electrons attract each other in valence shells

(c) the pairs of electrons tend to occupy such positions that minimise repulsions

(d) the pairs of electrons tend to occupy such positions that minimise distances from each other.

52. To which group, an element with atomic number 120 will belong?

(a) Group 12 (b) Group 17

(c) Group 10 (d) Group 2

Case - I : Read the passage given below and answer the following questions 53-55.

Hyperconjugation describes the orbital interaction between π-system and the adjacent σ bond of the substituent group in organic compounds. Thus the sufficient condition for the hyperconjugation are

(i) the presence of atleast one sp^2-hybrid carbon as in alkenes, carbocation and alkyl free radical.

(ii) the presence of α-carbon, with atleast one hydrogen, with respect of sp^2-carbon atom.

More the number of hydrogen atoms attached on the α-carbon(s) of the sp^2-hybrid carbon, more will the hyperconjugation, also called resonating structures of the compound.

Number of resonating structures due to hyper-conjugation = $n + 1$, where n is the number of α-hydrogen.

53. Hyperconjugation is possible in

(a) $\overset{+}{C}H_3$ (b) $C_6H_{11}\overset{+}{C}H_2$

(c) $CH_2 = CH_2$ (d) $(CH_3)_3CC \equiv CH$

54. Which of the following has highest number of hyperconjugative structure?

(a) 2-Ethylbut-2-ene (b) But-2-ene

(c) *tert*-Butyl cation (d) Hex-2-ene

55. The number of hyperconjugating structures shown by the carbocations are given below. Which one is not correctly matched?

(a) $CH_3 - \overset{+}{\underset{\displaystyle CH_3}{\underset{|}{C}}} - CH_3$ - 9 hyperconjugating structures

(b) $CH_3 - \overset{+}{C}H - CH_3$ - 8 hyperconjugating structures

(c) $CH_3 - \overset{+}{C}H_2$ - 3 hyperconjugating structures

(d) $\overset{+}{C}H_3$ - No hyperconjugating structures

SOLUTIONS

1. (b) : The photon capable of removing electron from first Bohr's orbit must possess energy

$= 13.6 \text{ eV} = 13.6 \times 1.602 \times 10^{-19} \text{ J}$

$= 21.787 \times 10^{-19} \text{ J}$

$\because \quad E = \dfrac{hc}{\lambda}$

$$21.787 \times 10^{-19} = \frac{6.625 \times 10^{-34} \times 3.0 \times 10^{8}}{\lambda}$$

$\therefore \quad \lambda = 912.24 \times 10^{-10} \text{ m} = 912.24 \text{ Å}$

This is longest λ because a photon having λ higher than this will possess energy lesser than required, as $E \propto \dfrac{1}{\lambda}$.

2. (a) **3. (c)**

4. (d) : The correct example is H_2O. NH_3 is pyramidal and bond angle is 107.8° in ammonia.

5. (c) : Carbon hydrides with general formula C_nH_{2n+2} are electron-precise hydrides like CH_4. They have a complete octet hence they do not behave as Lewis acid or Lewis base.

6. (b) : $(CH_3)_3C^+$ has the maximum number of α-hydrogens (*i.e.* 9) and hence, hyperconjugation is most useful in explaining its stability.

7. (d) : $\Delta v = \dfrac{0.1}{100} \times 10 = 10^{-2} \text{ m sec}^{-1}$;

Now, $\Delta v \cdot \Delta x = \dfrac{h}{4\pi m}$

$$\Delta x = \frac{6.625 \times 10^{-34}}{4 \times 10^{-2} \times 3.14 \times 200 \times 10^{-3}} = 2.64 \times 10^{-32} \text{ m}$$

8. (d) : Electronegativity decreases down the group.

9. (b) : Due to resonance stabilisation, C — Cl bond acquires partial double bond character.

$$H_2\overset{\curvearrowleft}{C}=CH-\overset{\curvearrowleft}{\underset{\cdot\cdot}{\underset{\cdot\cdot}{Cl}}}: \longleftrightarrow H_2\bar{\bar{C}}-CH=\overset{+}{\underset{\cdot\cdot}{\underset{\cdot\cdot}{Cl}}}: \text{ (+}R\text{-effect)}$$

Due to shortening of bond, Cl is firmly attached to carbon and is not easily substituted.

10. (d) : The correct order of energies of molecular orbitals in N_2 molecule is

$\sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$

11. (a) : $HCHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow 2Ag + HCOO^- + 4NH_3 + 2H_2O$

$HCHO \rightarrow HCOO^-$ (oxidation)

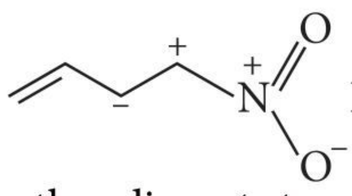
$[Ag(NH_3)_2]^+ \rightarrow Ag$ (reduction)

12. (b)

13. (d) : More the alkyl groups, lesser is the stability of carbanions.

14. (a) : $\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$= 109677\ (1/4 - 0) = \frac{109677}{4} = 27419.25\ cm^{-1}$

15. (a) :  In this, positive charges are present on the adjacent atoms, would be the least stable.

16. (b) : In ethyne, H — C ≡ C — H; C is *sp* hybridised.
In graphite, one C atom is attached to 3 other C atoms which are sp^2 hybridised.
In diamond, one C atom is attached to 4 other C atoms which are sp^3 hybridised.

17. (c) : Acidic oxides form acids while basic oxides form alkalies with water.

18. (a)

19. (c) : It is difficult to remove an electron from a highly electronegative element.

20. (b)

21. (d) : The configuration does not follow Hund's rule of maximum multiplicity because 3*p* will be fully filled before the electrons go to 4*s*.

22. (a) : Cation size is decreasing in the order :
$Na^+ > Mg^{2+} > Al^{3+}$

Al^{3+} has maximum polarisation effect and Na^+ has minimum polarisation effect.
The covalent nature is in the order : $AlCl_3 > MgCl_2 > NaCl$

23. (d) :

Element	%	No. of moles	Mole ratio	Whole no. ratio
P	27.3	27.3/12 = 2.27	1	1
Q	72.7	72.7/16 = 4.54	2	2

Empirical formula = PQ_2

24. (a) : SO_4^{2-} and BF_4^- have sp^3 hybridisation and are tetrahedral in shape.

25. (c) : (ii) and (iii) elements represent alkaline earth metals of Group-2 which have high first ionization enthalpy and less difference between the first and second ionisation enthalpies
For second group elements, the difference in successive *IE* is less. The compound formed will be MX_2.

26. (a)

27. (c) : The limiting line of Balmer series refers to the transition of electron from ∞ to 2nd orbit

$$\upsilon = c.\bar{\nu} = 3\times10^{10}\times109677\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$= 3.29\times10^{15}\left(\frac{1}{2^2} - 0\right) sec^{-1} \qquad (\because n_1 = 2, n_2 = \infty)$$

$$= 8.22 \times 10^{14}\ sec^{-1}$$

28. (c) : Only tropolone is non-benzenoid aromatic compound rest all are benzenoid aromatic compounds.

29. (d) : Molecular weight = $\frac{w}{V_{STP}} \times 22400$

$= \frac{0.24}{53.78} \times 22400 = 99.96 \approx 100\ g$

30. (d) : BrF_5 and $XeOF_4$ have sp^3d^2 hybridisation hence their shape is square pyramidal.

31. (a) : Enthalpy of bond dissociation of deuterium is higher (443.35 kJ mol^{-1}) than hydrogen (435.88 kJ mol^{-1}). Tritium is radioactive.

32. (c) : It has four O atoms as peroxide with oxidation number = –1 and one O atom with oxidation number = –2.
Hence, $x + 4(-1) + 1(-2) = 0$ or $x = +6$

33. (c) : $E_n = \frac{E_1}{n^2} \Rightarrow E_1 = 2^2 \times (-328) = -4 \times 328$ kJ mol^{-1}

Energy of 3rd shell, $E_3 = \frac{E_1}{9} = -\frac{4\times328}{9}$

$= -145.78$ kJ mol^{-1}

34. (d) : Sigma molecular orbitals are symmetrical around the bond axis while pi molecular orbitals are not symmetrical.

35. (d) : Size of atoms decreases with increase in atomic number in a period.

36. (c) : $SO_3^{2-} \rightarrow x + (-6) = -2 \Rightarrow x = +4$

$SO_4^{2-} \rightarrow x + (-8) = -2 \Rightarrow x = +6$

$S_2O_4^{2-} \rightarrow 2x + (-8) = -2 \Rightarrow x = +3$

$S_2O_6^{2-} \rightarrow 2x + (-12) = -2 \Rightarrow x = +5$

Hence $SO_4^{2-} > S_2O_6^{2-} > SO_3^{2-} > S_2O_4^{2-}$

37. (c) : (A) : $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
1 mole of Zn produces 2 g of H_2
0.5 mole of Zn will produce 1 g of H_2
(B) : $C_{70}H_{22}$
Molar mass = 862
Mass of atoms = $862/6.023 \times 10^{23} = 1.43 \times 10^{-21}$ g
(C) : 70 g of $Cl_2 = 6.023 \times 10^{23}$ molecules
35.5 g of $Cl_2 = 3.01 \times 10^{23}$ molecules
(D) : Molar mass of $SO_2 = 64 = 1$ mole
64 g of $SO_2 = 6.023 \times 10^{23}$ molecules

38. (d) : $\dot{\ddot{N}}=\ddot{O}$
For NO, the octet rule is not followed due to the presence of odd electrons on N.

39. (a) : $CaC_2 + 2D_2O \rightarrow C_2D_2 + Ca(OD)_2$

40. (b)

41. (b) : For $4f$; $n = 4$, $l = 3$,
$m_l = 7$ or $-3, -2, -1, 0, +1, +2, +3$

42. (b) : (iii) is a noble gas.

43. (b)

44. (d) : It is stabilised both by resonance effect and hyperconjugation.

45. (c) : D_2O has higher molecular mass and greater degree of association than H_2O and thus higher melting and boiling points.

46. (d) : The order of reactivity of carbonium ions is $1° > 2° > 3°$.
Carbon atom of carbonium ion is in sp^2 hybridisation state.

47. (c) : There is intermolecular hydrogen bonding in *para*-nitrophenol and intramolecular hydrogen bonding in *ortho*-nitrophenol.

48. (a) : Since in HNO_2 oxidation state of nitrogen can increase or decrease it can act as an oxidising as well as a reducing agent.

49. (a) : Due to very high B. D. E, it remains unreactive at room temperature.

50. (d) : $r_n = a_0 \times n^2$, $r_4 = a_0 \times 4^2 = 16a_0$

$$mv = 4 \times \frac{h}{2\pi r_4} = \frac{4h}{2\pi \times 16a_0} = \frac{h}{8\pi a_0} \text{ ; As } \lambda = \frac{h}{mv}$$

$\therefore \quad \lambda = 8\pi a_0$

51. (c) : The pairs of electrons tend to occupy such positions that place them farthest from each other and minimise repulsions.

52. (d) : $Z = 120$, [Rn] $7s^2\ 6d^{10}\ 5f^{14}\ 7p^6\ 8s^2$

53. (b) **54. (c)**

55. (b) : $CH_3 - \overset{+}{C}H - CH_3$ shows 6 hyperconjugating structures.

Oxygen in the Atmosphere Come From?

Scientists estimate that 50-80% of the oxygen production on Earth comes from the ocean. The majority of this production is from oceanic plankton — drifting plants, algae, and some bacteria that can photosynthesize. One particular species, Prochlorococcus, is the smallest photosynthetic organism on Earth. But this little bacteria produces upto 20% of the oxygen in our entire biosphere. That's a higher percentage than all of the tropical rainforests on land combined.

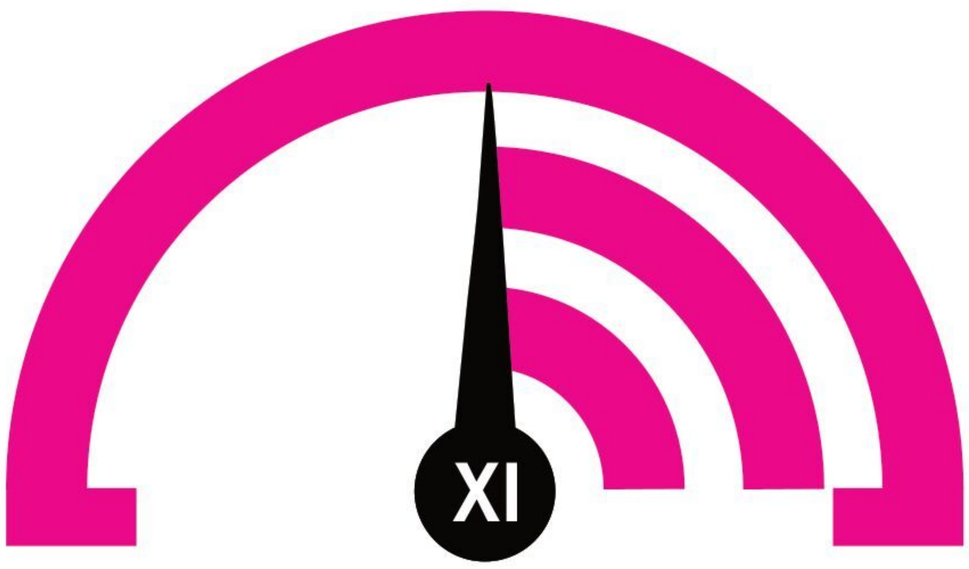
Fact about Our Brain

In the average adult human, the brain represents about 2% of the body weight. Remarkably, despite its relatively small size, the brain accounts for about 20% of the oxygen and, hence, calories consumed by the body.

Hydrogen and helium make up most of the Universe !

Helium and hydrogen make up most of the universe. Both of them account for 98% of all matter, being roughly 73% hydrogen, and 25% helium. All the other elements make up the remaining 2% of matter. The next in the list is oxygen, making up for a tiny 0.05%. Other atomic components in this order of magnitude are carbon, neon, nitrogen, and silicon.

MONTHLY TEST DRIVE



This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

Hydrogen | The *s*-Block Elements

Time Taken : 60 Min.

NEET

Only One Option Correct Type

1. Which of the following is the correct order of increasing reducing property?
(a) $H_2O < NaH < MgH_2$
(b) $H_2O < MgH_2 < NaH$
(c) $MgH_2 < NaH < H_2O$
(d) $NaH < H_2O < MgH_2$

2. At any temperature for the following reaction, (D & T are deuterium and tritium respectively) correct statement is
(i) $HCl + F \rightarrow HF + Cl$
(ii) $DCl + F \rightarrow DF + Cl$
(iii) $TCl + F \rightarrow TF + Cl$
(a) (i) is fastest
(b) (ii) is fastest
(c) (iii) is fastest
(d) All the above reactions occur at same rate.

3. Baking powder used to make cake is a mixture of starch, $NaHCO_3$ and $Ca(H_2PO_4)_2$. The function of $Ca(H_2PO_4)_2$ is
(a) to slow down the release of CO_2 gas
(b) it has acidic hydrogen and gives CO_2 when moistened with $NaHCO_3$
(c) to act as a filler
(d) none of these.

4. The set representing the correct order of ionic radius is
(a) $Li^+ > Be^{2+} > Na^+ > Mg^{2+}$
(b) $Na^+ > Li^+ > Mg^{2+} > Be^{2+}$
(c) $Li^+ > Na^+ > Mg^{2+} > Be^{2+}$
(d) $Mg^{2+} > Be^{2+} > Li^+ > Na^+$

5. In which the following cases H_2O_2 acts as a reducing agent in acidic medium?
(a) MnO_4^- (b) SO_3^{2-} (c) KI^- (d) $Cr_2O_7^{2-}$

6. Which of the following statements is true about $Ca(OH)_2$?
(a) It is used in the preparation of bleaching powder.
(b) It is a light blue solid.
(c) It does not possess disinfectant property.
(d) It is used in the manufacture of cement.

7. A dilute solution of H_2O_2 can be concentrated by
(a) drying it over anhydrous $CaCl_2$
(b) drying it over concentrated H_2SO_4
(c) drying it over anhydrous $MgSO_4$
(d) heating it under reduced pressure.

8. The stability of the following alkali metal chlorides follows the order
(a) LiCl > KCl > NaCl > CsCl
(b) CsCl > KCl > NaCl > LiCl
(c) NaCl > KCl > LiCl > CsCl
(d) KCl > CsCl > NaCl > LiCl

9. Sodium sulphate is soluble in water but barium sulphate is sparingly soluble because
(a) the hydration energy of Na_2SO_4 is more than its lattice energy while the lattice energy of $BaSO_4$ is more than its hydration energy
(b) the lattice energy has no role to play in solubility
(c) the lattice energy of Na_2SO_4 is more than its hydration energy
(d) none of these.

10. Which is not a property of hydrogen gas?
(a) Colourless (b) Odourless
(c) Tasteless (d) Non-inflammable

11. Consider the two reactions :
(i) $H_2O_2 + 2KI \rightarrow I_2 + 2KOH$
(ii) $H_2O_2 + O_3 \rightarrow 2O_2 + H_2O$
H_2O_2 behaves as
(a) an oxidising agent in both (i) and (ii)
(b) an oxidising agent in (i) and reducing agent in (ii)
(c) a reducing agent in (i) and oxidising agent in (ii)
(d) a reducing agent in both (i) and (ii).

12. On heating which of the following release CO_2 most easily?
(a) K_2CO_3 (b) Na_2CO_3
(c) $MgCO_3$ (d) $CaCO_3$

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** Saline hydrides are volatile, conducting and ionic solids.
Reason : Saline hydrides are compounds of hydrogen with most of the *p*-block elements.

14. **Assertion :** The thermal stability of hydrides of group-1 follows the order
LiH > NaH > KH > RbH > CsH.
Reason : Large anions form stable compounds with small cations.

15. **Assertion :** The first element (Li) of group I differs considerably from the rest of the elements of the same group.
Reason : Lithium has small ionic and atomic radii, less electropositive and ionization enthalpy, high polarising power of its cation and absence of *d* electrons in its valence shell compared to rest of the elements of the same group.

JEE MAIN / JEE ADVANCED

Only One Option Correct Type

16. $MgSO_4$ on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula?
(a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_4)_2$
(c) $MgCl_2 \cdot MgSO_4$ (d) $MgSO_4$.

17. Which of the following processes will produce hard water?
(a) Saturation of water with $CaCO_3$
(b) Saturation of water with $MgCO_3$
(c) Saturation of water with $CaSO_4$
(d) Addition of Na_2SO_4 to water

18. CO_2 gas along with solid (*Y*) is obtained when sodium salt (*X*) is heated. (*X*) is again obtained when CO_2 gas is passed into aqueous solution of (*Y*). (*X*) and (Y) are
(a) Na_2CO_3, Na_2O (b) Na_2CO_3, NaOH
(c) $NaHCO_3$, Na_2CO_3 (d) Na_2CO_3, $NaHCO_3$.

19. Which of the given order is not correct?
(a) $BeCO_3 < MgCO_3 < CaCO_3 < K_2CO_3$ (thermal stability)
(b) $Rb^+ > K^+ > Na^+ > Li^+$ (Mobility in aqueous solution)
(c) $MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$ (Solubility in water)
(d) *M*I < *M*Br < *M*Cl < *M*F (Covalent character alkali metals)

More than One Options Correct Type

20. When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water the sodium ions are exchanged with
(a) H^+ ions (b) Ca^{2+} ions
(c) SO_4^{2-} ions (d) Mg^{2+} ions.

21. Which of the given statements are correct?
(a) On decomposition of H_2O_2, O_2 gas is released.
(b) 2-Ethylanthraquinone is used to prepare H_2O_2.
(c) On heating $Pb(NO_3)_2$ and $NaNO_3$, N_2 gas is released.
(d) In the preparation of sodium peroxoborate, H_2O_2 is treated with sodium metaborate.

22. Select the correct statements about barium.
(a) It shows photoelectric effect.
(b) It is silvery white metal.
(c) It forms $Ba(NO_3)_2$ which is used in preparation of green fire.
(d) Its ionisation energy is less than radium.

23. Which of the following statements are not correct about lithium?
(a) Lithium is least reactive of all alkali metals.
(b) It is the weakest reducing agent among all alkali metals.
(c) It forms no acetylides with acetylene.
(d) $LiHCO_3$ is a white crystalline solid.

Integer / Numerical Value Type

24. The volume strength of 1.5 N H_2O_2 is_____.

25. Calculate the strength (in g/L) of 10 volume solution of H_2O_2.

26. *X* is used for immobilising the affected part of organ where there is a sprain. *X* is obtained on heating gypsum at 393 K. The number of expelled water molecules when *X* is obtained by heating 2 molecules of gypsum is _____.

Comprehension Type

$$KO_2 + S \xrightarrow{\Delta} (A) \xrightarrow{CaCl_2} (B), \text{ ppt}$$

$$(B) \xrightarrow[\text{heating}]{\text{Carbon, strong}} (C) + D(g)$$

$$(C) + D(g) \xrightarrow{\text{dil. HCl}} (E)\ (g) \text{ turns lead acetate paper black}$$

$$Ca + H_2 \xrightarrow{\Delta} F(\text{Solid})$$

$$(F) + CaCl_2 \xrightarrow{\Delta} G(\text{Solid})$$

$$(G) + H_2O \longrightarrow H(\text{Gas})$$

27. As per given sequence of reaction (*B*) is
(a) CaS (b) $CaSO_4$
(c) CaO (d) $KCaCl_3$

28. As per given sequence of reaction (*H*) is
(a) HCl (b) CaHCl
(c) Cl_2 (d) H_2

Matrix Match Type

29. Match List I (substances) with List II (composition) and select the correct answer using the code given the lists.

	List I (Substances)		**List II (Composition)**
P.	Plaster of Paris	(i)	$CaSO_4 \cdot 2H_2O$
Q.	Epsomite	(ii)	$CaSO_4 \cdot \frac{1}{2} H_2O$
R.	Kieserite	(iii)	$MgSO_4 \cdot 7H_2O$
S.	Gypsum	(iv)	$MgSO_4 \cdot H_2O$
		(v)	$CaSO_4$

	P	**Q**	**R**	**S**
(a)	(iii)	(iv)	(i)	(ii)
(b)	(ii)	(iii)	(iv)	(i)
(c)	(i)	(ii)	(iii)	(v)
(d)	(iv)	(iii)	(ii)	(i)

30. Match the processes given in List I with reagents mentioned in List II and choose the correct answer using the codes given below the lists.

	List I		**List II**
P.	Hard water	1.	*Ortho* hydrogen
Q.	$LaH_{2.8}$	2.	Radioactive isotope
R.	Same spin of protons	3.	Interstitial hydride
S.	Tritium	4.	$MgSO_4$

	P	**Q**	**R**	**S**
(a)	3	2	4	1
(b)	2	3	4	1
(c)	4	3	1	2
(d)	3	1	2	4

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted	.....
No. of questions correct	.....
Marks scored in percentage	.....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

BRUSH UP

for

NEET/JEE

CLASS-XII

Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

Unit 4

The *p* - Block Elements (Group 15 to 18) | The *d* - and *f* - Block Elements

The *p*-Block Elements (Group 15 to 18)

Group 15 Elements (Nitrogen Family)

Group 15 Elements (ns^2np^3)

Element	At. No.	Electronic Configuration	Oxidation State
Nitrogen (N)	7	[He] $2s^2 2p^3$	–3, –2, –1, 0, +1, +2, +3, +4, +5
Phosphorus (P)	15	[Ne] $3s^2 3p^3$	–3, +3, +5
Arsenic (As)	33	[Ar] $3d^{10} 4s^2 4p^3$	–3, +3, +5
Antimony (Sb)	51	[Kr] $4d^{10} 5s^2 5p^3$	–3, +3, +5
Bismuth (Bi)	83	[Xe] $4f^{14} 5d^{10} 6s^2 6p^3$	+3, +5
Moscovium (Mc)	115	[Rn] $5f^{14} 6d^{10} 7s^2 7p^3$	–

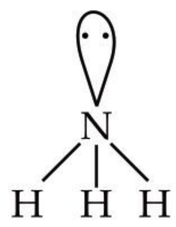
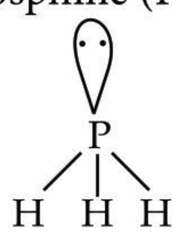
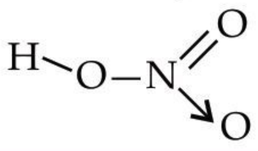
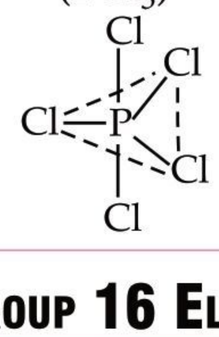
General Trends

Increasing trends	Decreasing trends
Atomic size	Ionization energy
M.pt. / B.pt. increases from N → As	Electronegativity
Metallic character	M.pt. / B.pt. decreases, As → Bi
Density	Tendency of covalent bonding
Tendency of lower oxidation state + 3	Thermal stability of hydrides
Reducing character of hydrides (EH_3)	Bond angle in hydrides (EH_3)
Ionic character of compounds	Basic nature of hydrides (EH_3)

Exceptions :

- Except N and Bi, All elements exhibit allotropy.
- B.pt. of EH_3: $PH_3 < AsH_3 < NH_3 < SbH_3 < BiH_3$

Important Compounds of Nitrogen Family

Structure	Preparation	Properties	Uses
Ammonia (NH_3) 	$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$; $\Delta H_f^\circ = -46.1$ kJ/mol (*Haber's process*)	NH_3 → O_2: $N_2 + H_2O$; Cl_2: $NH_4Cl + N_2$ (If NH_3 excess), $NCl_3 + HCl$ (If Cl_2 excess); O_2, Pt: $NO + H_2O$; AgCl: $[Ag(NH_3)_2]Cl$	In refrigerators, manufacturing of rayon, HNO_3 (*Ostwald's process*), $NaHCO_3$ (*Solvay's process*), nitrogenous fertilizers.
Phosphine (PH_3) 	$Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3\uparrow$	PH_3 → $CuSO_4$: $Cu_3P_2 + H_2SO_4$; HCl: $PH_4^+Cl^-$; O_2: H_3PO_4; N_2O: $N_2 + H_3PO_4$	For production of smoke screens. Phosphine in combination with acetylene is used in *Holme's signals*.
Nitric acid (HNO_3) 	$NaNO_3 + H_2SO_4 \xrightarrow{\Delta} NaHSO_4 + HNO_3$	HNO_3 → SO_2: $H_2SO_4 + NO_2$; Sn: $H_2SnO_3 + NO_2 + H_2O$; HCl: $H_2O + NOCl + Cl_2$	As fertilizers, explosives, perfumes, dyes and medicines. As oxidiser in rocket fuels.
Phosphorus pentachloride (PCl_5) 	$P_4 + 10Cl_2 \longrightarrow 4PCl_5$ (white) (Excess)	PCl_5 → P_4O_{10}: $POCl_3$; SO_2: $POCl_3 + SOCl_2$; P_4S_{10}: $PSCl_3$; H_2O (in excess): $H_3PO_4 + HCl$	As chlorinating and dehydrating agent.

Group 16 Elements (Oxygen Family)

Group 16 Elements (ns^2np^4)

Element	At. No.	Electronic Configuration	Oxidation State
Oxygen (O)	8	[He] $2s^2 2p^4$	–2, –1, +1, +2
Sulphur (S)	16	[Ne] $3s^2 3p^4$	–2, +2, +4, +6
Selenium (Se)	34	[Ar] $3d^{10} 4s^2 4p^4$	–2, +2, +4, +6
Tellurium (Te)	52	[Kr] $4d^{10} 5s^2 5p^4$	–2, +2, +4, +6
Polonium (Po)	84	[Xe] $4f^{14} 5d^{10} 6s^2 6p^4$	+2, +4, +6
Livermorium (Lv)	116	[Rn] $5f^{14} 6d^{10} 7s^2 7p^4$	–

General Trends

Increasing trends	Decreasing trends
Atomic size	Ionization energy
Density	Electronegativity
Ionic radius	Electron affinity
M.pt./B.pt. increase, O → Te	M.pt./B.pt. decreases Te → Po
Metallic character	Thermal stability of H_2E
Acidic nature of hydrides (H_2E)	Bond angle in hydrides (H_2E)
Reducing character increases	$E-E$ bond strength

Exceptions

- O shows tendency of $p\pi$-$p\pi$ bonding, others can form $d\pi$-$p\pi$ bonding.
- EA_1 of O < EA_1 of S
- S shows some tendency of catenation.

Anomalous Behaviour of Oxygen

Oxygen differs from the rest of the elements of oxygen family due to

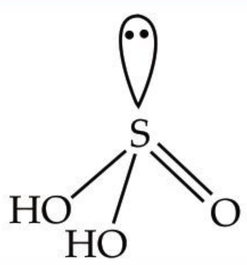
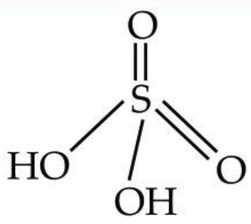
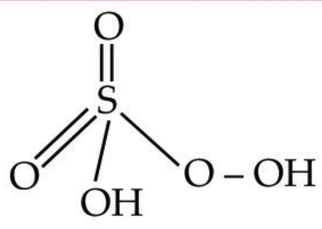
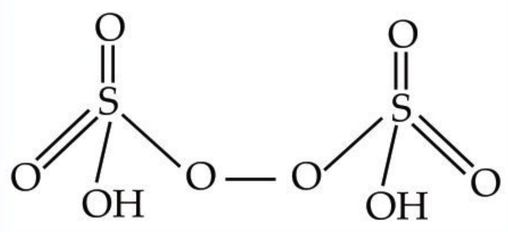
- small size

- high electronegativity and
- non-availability of *d*-orbitals.

Points of difference :

- Oxygen is a diatomic gas while others are solids.
- Oxygen exhibits oxidation states of –2, –1 and +2 only while other members show both negative and positive oxidation states like –2, +2, +4 and +6.
- Due to high electronegativity of oxygen, hydrogen bonding is present in water.
- Oxygen is highly non-metallic due to high electronegativity.
- Oxygen is paramagnetic while others are diamagnetic.
- Oxygen is capable of forming $p\pi$-$p\pi$ bonds with other elements of smaller size, like C, N, etc.

Some Important Oxoacids of Sulphur

Oxoacid	Oxidation state, basicity and salt type	Structure	Properties
Sulphurous acid, H_2SO_3	S = +4, dibasic, and forms two series of salts, sulphites (SO_3^{2-}) and bisulphites (HSO_3^-)		– acts as reducing agent as well as oxidising agent. – exists only in solution.
Sulphuric acid (oil of vitriol), H_2SO_4	S = +6, dibasic and forms two series of salts, sulphates (SO_4^{2-}) and bisulphates (HSO_4^-)		– highly corrosive acts as oxidising agent and dehydrating agent.
Peroxomonosulphuric acid (Caro's acid), H_2SO_5	S = +6, monobasic and forms single type of salt, peroxymonosulphates (HSO_5^-)		– white, crystalline and hygroscopic solid. – powerful oxidising agent.
Peroxodisulphuric acid (Marshall's acid), $H_2S_2O_8$	S = +6 and forms single type of salt, peroxydisulphates ($S_2O_8^{2-}$)		– colourless, crystalline and hygroscopic solid. – strong oxidising agent.

Group 17 Elements (Halogen Family)

Group 17 Elements (ns^2np^5)

Element	At. No.	Electronic Configuration	Oxidation State
Fluorine (F)	9	$[He]2s^2 2p^5$	–1
Chlorine (Cl)	17	$[Ne]3s^2 3p^5$	–1, +1, +3, +5, +7
Bromine (Br)	35	$[Ar]3d^{10} 4s^2 4p^5$	–1, +1, +3, +5, +7
Iodine (I)	53	$[Kr]4d^{10} 5s^2\ 5p^5$	–1, +1, +3, +5, +7
Astatine (At)	85	$[Xe]4f^{14} 5d^{10} 6s^2 6p^5$	–
Tennessine (Ts)	117	$[Rn]5f^{14} 6d^{10} 7s^2 7p^5$	–

General Trends

Increasing trends	Decreasing trends
Atomic size	Ionisation energy
Ionic radii	Electronegativity
M.pt./B.pt.	Electron affinity
Intensity of colour	Chemical reactivity
Electropositive character	$E°$ values
Acidic nature of hydrides (HX)	Oxidising power
Reducing nature of hydrides (HX)	Thermal stability of HX

- **Exceptions**
  - EA_1 of Cl > EA_1 of F
  - F shows oxidation state of – 1 except in HOF where it shows an oxidation state of +1; others show oxidation states – 1, + 1, + 3, + 5, + 7.

Oxoacids

Name	O.N. of *X*	F	Cl	Br	I
Hypohalous acid, HXO	+1	HOF	HOCl	HOBr	HOI
Halous acid, HXO_2	+3	–	$HClO_2$	–	–
Halic acid, HXO_3	+5	–	$HClO_3$	$HBrO_3$	HIO_3
Perhalic acid, HXO_4	+7	–	$HClO_4$	$HBrO_4$	HIO_4

Thermal stability, acidic strength decreases

HXO_4, HXO_3, HXO_2, HXO

Oxidising nature increases

Interhalogen Compounds

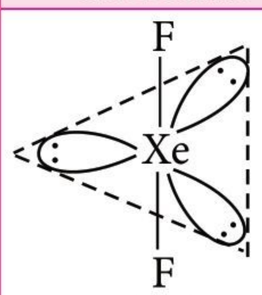
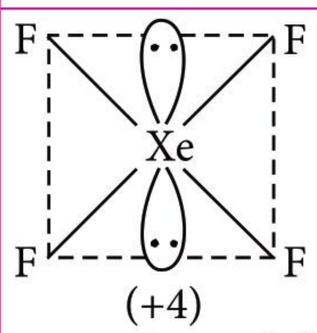
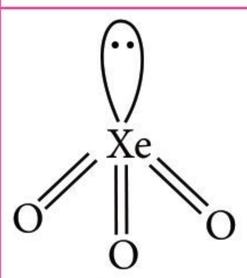
Type	Hybridisation	Shape	Geometry
XX'	sp^3	Linear	Tetrahedral
XX'_3	sp^3d	T-shaped	Trigonal bipyramidal
XX'_5	sp^3d^2	Square pyramidal	Octahedral
XX'_7	sp^3d^3	Pentagonal bipyramidal	Pentagonal bipyramidal

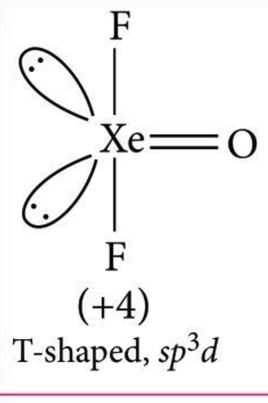
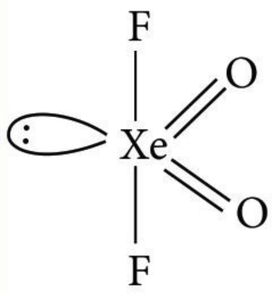
Group 18 Elements (Noble Gases)

Group 18 Elements (ns^2np^6)

Element	Atomic no.	Electronic configuration
Helium (He)	2	$1s^2$
Neon (Ne)	10	[He] $2s^2\ 2p^6$
Argon (Ar)	18	[Ne] $3s^2\ 3p^6$
Krypton (Kr)	36	[Ar] $3d^{10}\ 4s^2\ 4p^6$
Xenon (Xe)	54	[Kr] $4d^{10}\ 5s^2\ 5p^6$
Radon (Rn)	86	[Xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^6$
Oganesson (Og)	118	[Rn] $5f^{14}\ 6d^{10}\ 7s^2\ 7p^6$

Compounds of Xenon

Compound	Structure	Preparation	Properties
XeF_2 (Xenon difluoride)	 (+2) Linear, sp^3d	$Xe + F_2 \xrightarrow[400°C]{\text{Ni tube}} XeF_2$ (2 : 1) $Xe + O_2F_2 \xrightarrow{-178°C} XeF_2 + O_2$	$XeF_2 \xrightarrow{H_2} Xe + 2HF$ $XeF_2 \xrightarrow{H_2O} Xe + 2HF + \frac{1}{2}O_2$ $XeF_2 \xrightarrow[BF_3]{I_2} 2IF + Xe$ $XeF_2 \xrightarrow{2HCl} Xe + 2HF + Cl_2$ – Acts as fluorinating agent.
XeF_4, (Xenon tetrafluoride)	 (+4) Square planar, sp^3d^2	$Xe + F_2 \xrightarrow[600°C]{\text{Ni tube}} XeF_4$ (1 : 5)	– Colourless, crystalline solid with melting point, 117.1°C. – $XeF_4 + 2H_2 \longrightarrow Xe + 4HF$ – Undergoes disproportionation in water. $6XeF_4 + 12H_2O \longrightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$ – $XeF_4 + SbF_5 \longrightarrow [XeF_3]^+ [SbF_6]^-$ – Acts as fluorinating agent.
XeO_3, (Xenon trioxide)	 (+6) Pyramidal, sp^3	Complete hydrolysis of XeF_4 and XeF_6 : $6XeF_4 + 12H_2O \longrightarrow 4Xe + 2XeO_3 + 3O_2 + 24HF$ $XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HF$	– Colourless, highly explosive and powerful oxidising agent. – Undergoes disproportionation when dissolved in alkali. $2XeO_3 + 4OH^- \longrightarrow Xe + O_2 + XeO_6^{4-} + 2H_2O$

$XeOF_2$, (Xenon oxydifluoride)	 (+4) T-shaped, sp^3d	Partial hydrolysis of XeF_4 : $XeF_4 + H_2O \longrightarrow XeOF_2 + 2HF$	— Unstable
XeO_2F_2 (Xenon dioxy-difluoride)	 Distorted trigonal bipyramidal, sp^3d	Partial hydrolysis of $XeOF_4$ or XeF_6 : $XeOF_4 + H_2O \longrightarrow XeO_2F_2 + 2HF$ $XeF_6 + 2H_2O \longrightarrow XeO_2F_2 + 4HF$ Action of SiO_2 on $XeOF_4$: $2XeOF_4 + SiO_2 \longrightarrow 2XeO_2F_2 + SiF_4$	— Colourless solid. — Undergoes hydrolysis readily. $XeO_2F_2 + H_2O \longrightarrow XeO_3 + 2HF$

- XeF_6 cannot be stored in glass vessels because with glass, it form explosive XeO_3

  $2XeF_6 + SiO_2 \longrightarrow 2XeOF_4 + SiF_4$

  $2XeOF_4 + SiO_2 \longrightarrow 2XeO_2F_2 + SiF_4$

Uses of Noble Gases

- Helium is used as breathing mixture (or oxygen dilutant) for divers.
- Mixture of O_2 and He is used in the treatment of asthma.
- Neon lighting is used for advertising.
- Argon is primarily used to create an inert atmosphere in light bulbs, welding and fluorescent bulbs.
- The light emitted by krypton in an electric discharge tube is used for runway and approach lights in airports.
- Xenon is used in electrical flash bulbs for high speed photography.

The *d*- and *f*- Block Elements

Transition Elements

Their general electronic configuration is $(n-1)d^{1-10}\ ns^{0-2}$ where, n is the outermost shell.

Series	Element
First transition series ($3d$-series)	Sc (At. no. 21) to Zn (At. no. 30)
Second transition series ($4d$-series)	Y (At. no. 39) to Cd (At. no. 48)
Third transition series ($5d$-series)	La (At. no. 57), Hf (At. no. 72) to Hg (At. no. 80)
Fourth transition series ($6d$-series)	Ac (At. no. 89), Rf (At. no. 104) to Cn (At. no. 112)

Metallic Character

- Metallic bonding is due to possession of one or two electrons in the outermost shell and relatively low ionisation energies. All the transition elements are metals having *hcp*, *ccp* or *bcc* lattice except mercury which is a liquid.

Oxidation States

- They show variable oxidation states due to involvement of $(n-1)d$ and outer ns-electrons in bonding as the energies of ns and $(n-1)d$ subshells are nearly equal.
- When ns and $(n-1)d$-electrons participate in bonding → show higher oxidation state.

Magnetic Properties

- Magnetic moment, $\mu_{eff} = \sqrt{n(n+2)}$ B.M.
  (where, n = number of unpaired electrons)
- Magnetic character $\propto n$

Atomic and Ionic Radii

- Atomic radii decrease in the series with increase in atomic number because nuclear charge increases. After midway, decrease is small because of increased shielding effect of *d*-electrons. Ionic radii follow the same trend as the atomic radii.

Ionisation Energies

- IE_1 of 5*d*-elements are higher than those of the 3*d* and 4*d*-elements. This is due to greater effective nuclear charge acting on outer valence electrons because of the weak shielding of the nucleus by 4*f*-electrons.

Electrode Potential (*E*°)

- For the 3*d*-transition metals the $E°(M^{2+}/M)$ values are :

V	Cr	Mn	Fe	Co	Ni	Cu	
–1.18	–0.91	–1.18	–0.44	–0.28	–0.25	0.34	(Volts)

The irregular trend is due to variation in ionisation energies and sublimation energies. Except copper 3*d*-elements are good reducing agents but weaker than *s*-block elements.

Melting and Boiling Points

- These metals have very high melting and boiling points due to stronger metallic bonding.
- The melting point of the transition elements first rise to a maximum and then fall as the atomic number increases.

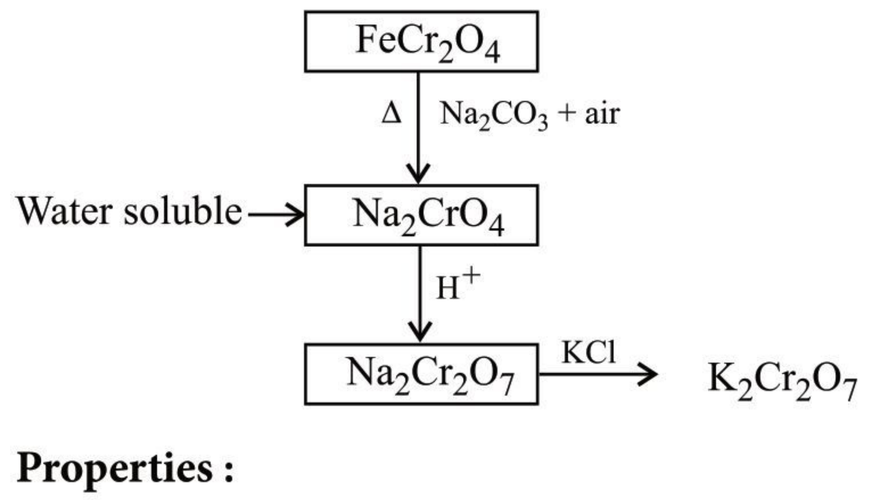
Alloy Formation

- Alloys are readily formed by these metals because of similar radii and other characteristics of transition metals.
- The alloys so formed are hard and have often high melting points and are also have considerable industrial importance.

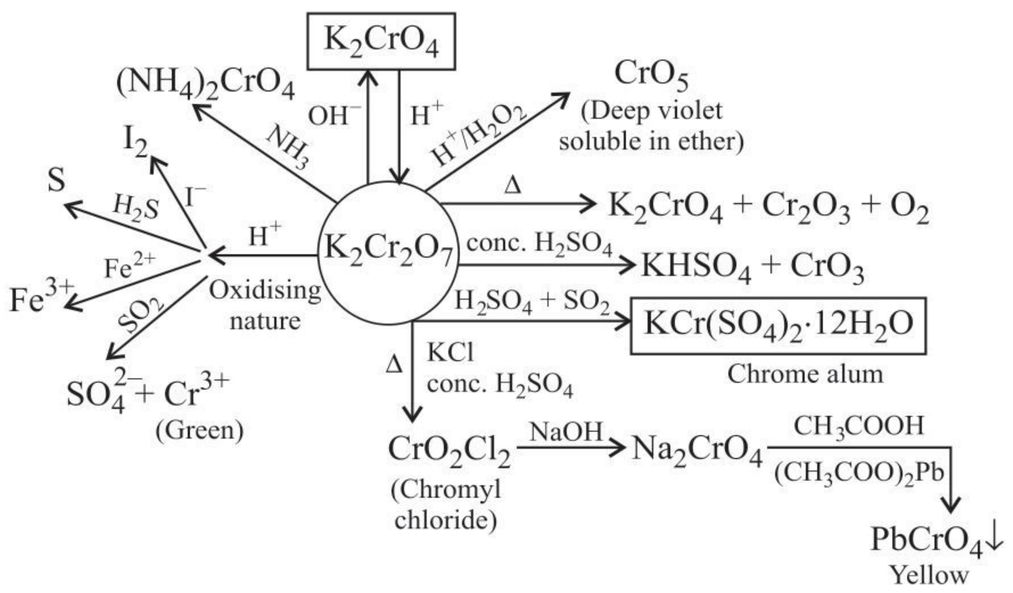
Some Important Compounds of Transition Elements

Potassium Dichromate ($K_2Cr_2O_7$)

- **Preparation :**



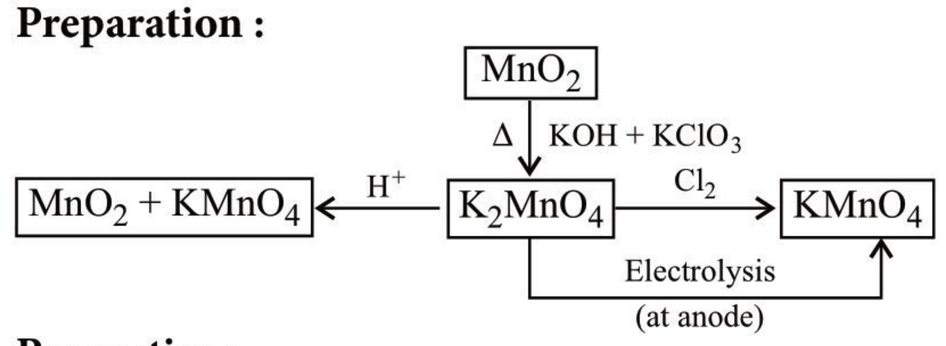
- **Properties :**



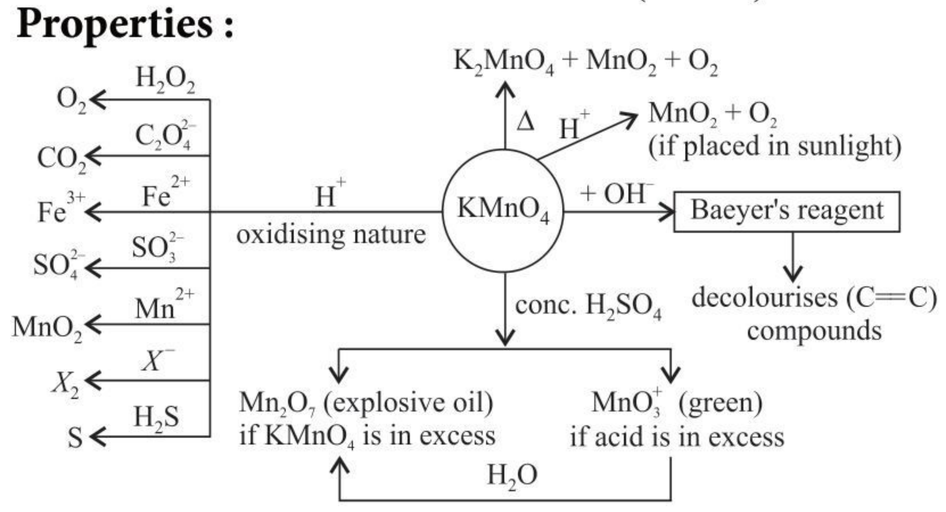
- **Uses :** It is used
  - in dyeing and calico printing,
  - in chrome tanning in leather industry,
  - as a volumetric reagent in laboratory for the estimation of ferrous ions, iodide ions, etc.

Potassium Permanganate ($KMnO_4$)

- **Preparation :**



- **Properties :**



- **Uses :** It is used
  - as an oxidising agent in the laboratory and industry,
  - as a disinfectant and germicide,
  - in qualitative and quantitative analysis.

INNER TRANSITION ELEMENTS

- **Lanthanoids :** The elements with atomic numbers 58 to 71 *i.e.*, cerium to lutetium (which come immediately after lanthanum, $Z = 57$) are called *lanthanoids*.
- **Actinoids :** The elements with atomic number 90 to 103 *i.e.*, thorium to lawrencium (which come immediately after actinium, $Z = 89$) are called *actinoids*.
- They are called *f*-block elements because last electron enters into *f*-orbital.
- General electronic configuration : $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$

General Characteristics

INNER TRANSITION ELEMENTS

LANTHANOIDS

- They show mainly +3 oxidation state. +2 and +4 oxidation states also exist. They have greater shielding effect as compared to actinoids. Most of their ions are coloured. They are paramagnetic and their magnetic properties can be easily explained. Less tendency to form complexes. Except promethium, these are non-radioactive substances. These are less basic.
- The regular decrease in the size of lanthanoid atoms and ions from La/La^{3+} to Lu/Lu^{3+} is known as *lanthanoid contraction*. It is due to greater effect of the increased nuclear charge than that of the screening effect, which is attributed to the imperfect shielding of one electron by another in the same sub-shell.

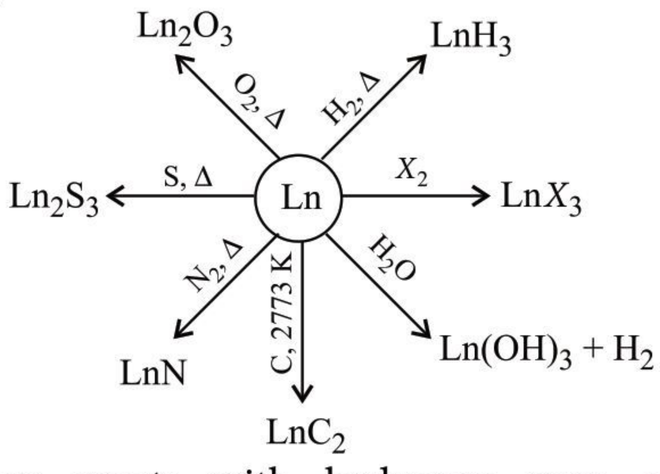
ACTINOIDS

- In addition to +3 oxidation state, actinoid also show higher oxidation states like +4, +5, +6 and +7. They have poor shielding effect. Most of the actinoid ions are also coloured. They are also paramagnetic, but their magnetic properties cannot be easily explained. More tendency to form complexes. These are all radioactive. These are more basic.
- There is a regular decrease in ionic radii with increase in atomic number form Th to Lr. This is called *actinoid contraction* analogous to the lanthanoid contraction. It is caused due to imperfect shielding of one 5*f* electron by another in the same shell. This results in increase in the effective nuclear charge which causes contraction in size of the electron cloud.

Consequences of Lanthanoid Contraction

- Separation of lanthanoids is difficult because of small difference in their size. Therefore, lanthanoids are mainly separated by ion exchange method.
- Basic strength of hydroxides decrease from Ce to Lu Thus, $La(OH)_3$ is most basic whereas $Lu(OH)_3$ is least basic.
- Radii of elements in same group from 4^{th} to 12^{th} groups in 4*d* and 5*d* series are very close and these elements in each group are called *chemical twins*. *e.g.*, Zr and Hf, Nb and Ta, etc.
- The properties of complex formation increase from La to Lu because of decrease in size and increase in "charge : size" ratio.
- There is a very slight increase in electronegativity from La to Lu.

Chemical Properties of Lanthanoids and Actinoids



- Uranium reacts with hydrogen even at room temperature, though the reaction is faster at 250°C giving UH_3 as black pyrophoric powder.

$$U + H_2 \xrightarrow{250°C} UH_3$$

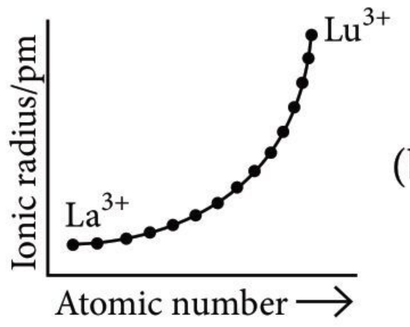
UH_3 is very reactive used for making other compounds.

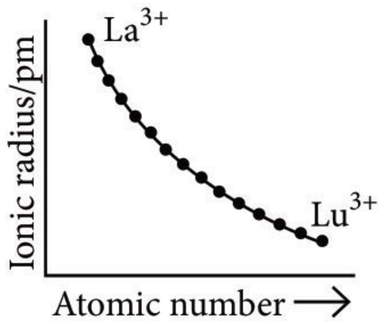
$$2UH_3 + 4H_2O \longrightarrow 2UO_2 + 7H_2$$
$$UH_3 + 3HCl \longrightarrow UCl_3 + 3H_2$$
$$2UH_3 + 4Cl_2 \longrightarrow 2UCl_4 + 3H_2$$
$$U + O_2 \longrightarrow U_3O_8$$

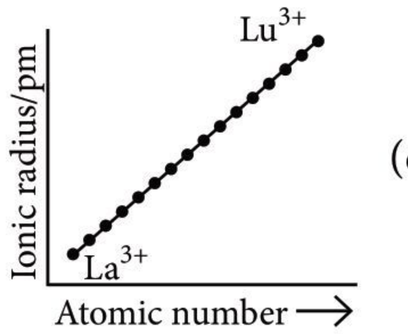
WRAP it up!

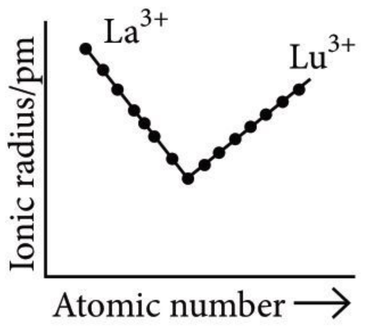
MCQs Type

1. Which of the following graphs shows correct trends in the size of +3 ions of lanthanides?

(a) 

(b) 

(c) 

(d) 

2. A certain compound on burning in air forms three oxides. One of the oxides turned lime water milky, the other turned anhydrous $CuSO_4$ blue and third formed a solution of pH = 9. Compound is formed of

(a) S, N and H (b) S, N and C
(c) S, C and H (d) S, H and Na

3. Among the following transition metal ions, the one where all metal ions have $3d^2$ electronic configuration is

(a) $Ti^{3+}, V^{2+}, Cr^{3+}, Mn^{4+}$
(b) $Ti^{+}, V^{4+}, Cr^{6+}, Mn^{7+}$
(c) $Ti^{2+}, V^{3+}, Cr^{2+}, Mn^{3+}$
(d) $Ti^{2+}, V^{3+}, Cr^{4+}, Mn^{5+}$

4. A transition metal exists in its highest oxidation state. It is expected to behave as

(a) a chelating agent
(b) electrondonating species
(c) an oxidizing agent
(d) a reducing agent.

5. Which of the following statements is incorrect?

(a) XeF_2 is a powerful reducing agent.
(b) XeF_2 is obtained by the direct reaction between F_2 and Xe at high pressure.
(c) XeF_2 undergoes alkaline hydrolysis to give O_2 and Xe.
(d) XeF_2 contains two bond pairs and three lone pairs.

6. The true statement for the acids of phosphorus, H_3PO_2, H_3PO_3 and H_3PO_4 is

(a) the order of their acidity is $H_3PO_4 > H_3PO_3 > H_3PO_2$
(b) all of them are reducing in nature
(c) all of them are tribasic acids
(d) the geometry of phosphorus is tetrahedral in all the three.

7. Select the false statement.

(a) Bleaching powder loses its bleaching property when it is kept in an open bottle for a long time.
(b) Sulphur melts to a clear mobile liquid at 119 °C but on further heating above 160 °C it again becomes viscous.
(c) Graphite is used as a solid lubricant.
(d) Rhombic sulphur is prepared by melting monoclinic sulphur in a dish and cooling till crust is formed.

8. The manganate and permanganate ions are tetrahedral, due to

(a) the π-bonding involves overlap of *d*-orbitals of oxygen with *d*-orbitals of manganese
(b) the π-bonding involves overlap of *p*-orbitals of oxygen with *d*-orbitals of manganese
(c) there is no π-bonding
(d) the π-bonding involves overlap of *p*-orbitals of oxygen with *p*-orbitals of manganese.

(NEET 2019)

9. In cyclotrimetaphosphoric acid, number of P—O—P bonds, P =O bonds and P—OH bonds are respectively

(a) 6, 3, 3 (b) 5, 0, 3
(c) 4, 3, 0 (d) 3, 3, 3

10. Number of moles of $K_2Cr_2O_7$ reduced by one mole of Sn^{2+} ion is

(a) $\frac{1}{3}$ (b) 3 (c) $\frac{1}{6}$ (d) 6

11. Which of the following statements is incorrect?

(a) ONCl and ONO^- are isoelectronic.
(b) O_3 molecule is bent.
(c) Ozone is violet-black in solid state.
(d) Ozone is diamagnetic gas.

12. Urea reacts with water to form *A* which will decompose to form *B*. *B* when passed through $Cu^{2+}_{(aq)}$, deep blue colour solution *C* is formed. What is the formula of *C* from the following?

(a) $CuSO_4$ (b) $[Cu(NH_3)_4]^{2+}$

(c) $Cu(OH)_2$ (d) $CuCO_3 \cdot Cu(OH)_2$

(NEET 2020)

13. Among the following transition elements, pick out the element with highest second ionization energy.

(a) V($Z = 23$) (b) Cr($Z = 24$)

(c) Mn($Z = 25$) (d) Cu($Z = 29$)

14. The stability of interhalogen compounds follows the order :

(a) $IF_3 > BrF_3 > ClF_3$ (b) $BrF_3 > IF_3 > ClF_3$

(c) $ClF_3 > BrF_3 > IF_3$ (d) $ClF_3 > IF_3 > BrF_3$

15. Which one of the following statements is incorrect?

(a) pK_a value of HI (strongest halogen acid) is most positive.

(b) High H—F bond strength makes H—F a weak acid in dilute aqueous solution.

(c) Helium and Neon do not form clathrates.

(d) K_a values of *HX* is in order HF < HCl < HBr < HI.

16. The lanthanide ion that would show colour is

(a) Lu^{3+} (b) Sm^{3+} (c) La^{3+} (d) Gd^{3+}

(JEE Main 2019)

17. Which of the following hydrides would be most basic?

(a) PH_3 (b) AsH_3 (c) NH_3 (d) SbH_3

18. MnO_4^- is of intense pink colour, though Mn is in (+7) oxidation state. It is due to

(a) oxygen gives colour to it

(b) charge transfer when oxygen gives its electron to Mn making it Mn (+VI) hence, coloured

(c) charge transfer when Mn gives its electron to oxygen

(d) none of the above is correct.

19. The actinoids exhibit more number of oxidation states in general than the lanthanoids. This is because

(a) the 5*f* orbitals extend farther from the nucleus than the 4*f* orbitals.

(b) the 5*f* orbitals are more buried than the 4*f* orbitals.

(c) there is a similarity between 4*f* and 5*f* orbitals in their angular part of the wave function.

(d) the actinoids are more reactive than the lanthanoids.

20. The shape/structure of $[XeF_5]^-$ and XeO_3F_2, respectively, are

(a) pentagonal planar and trigonal bipyramidal

(b) octahedral and square pyramidal

(c) trigonal bipyramidal and trigonal bipyramidal

(d) trigonal pibyramidal and pentagonal planar.

(JEE Main 2020)

21. $FeCr_2O_4 \xrightarrow{I} Na_2CrO_4 \xrightarrow{II} Cr_2O_3 \xrightarrow{III} Cr$

I, II and III are

	I	II	III
(a)	Na_2CO_3/air	H^+/NH_4Cl	Al
(b)	NaOH/air	C	C
(c)	Na_2CO_3/air	C	C
(d)	NaOH/air	Al	C

22. Which of the following pairs of transition metal ions are the stronger oxidizing agents in aqueous solution?

(a) V^{2+} and Cr^{2+} (b) Ti^{2+} and Cr^{2+}

(c) Mn^{3+} and Co^{3+} (d) V^{2+} and Fe^{2+}

23. The ease of hydrolysis of trichlorides of group 15 elements decreases in the order

(a) $NCl_3 > PCl_3 > AsCl_3 > SbCl_3 > BiCl_3$

(b) $PCl_3 > NCl_3 > AsCl_3 > SbCl_3 > BiCl_3$

(c) $AsCl_3 > NCl_3 > PCl_3 > SbCl_3 > BiCl_3$

(d) $SbCl_3 > BiCl_3 > PCl_3 > NCl_3 > AsCl_3$

24. The correct statement regarding, (i) HClO, (ii) $HClO_2$, (iii) $HClO_3$ and (iv) $HClO_4$, is/are

(a) the number of Cl=O bonds in (ii) and (iii) together is two

(b) the number of lone pairs of electrons on Cl in (ii) and (iii) together is three

(c) the hybridization of Cl in (iv) is sp^2

(d) amongst (i) to (iv), the strongest acid is (i).

25. Consider the following statements

I. $La(OH)_3$ is least basic among hydroxides of lanthanides.

II. Zr^{4+} and Hf^{4+} possess almost the same ionic radii.

III. Ce^{4+} can act as an oxidizing agent.

Which of the above is/are true?

(a) I and III (b) II and III

(c) II only (d) I and II

NUMERICAL VALUE TYPE

26. Total number of oxides which are colourless in the given list of oxides is NO, N_2O, N_2O_3, $N_2O_{4(l)}$, N_2O_5

27. The "spin only" magnetic moment [in unit of Bohr magneton (μ_B)] of Ni^{2+} in aqueous solution would be (At. No. Ni = 28)

28. Consider the following reactions

$$NaCl + K_2Cr_2O_7 + H_2SO_4 \rightarrow A + \text{side products}$$
(conc.)

$$(A) + NaOH \rightarrow (B) + \text{side products}$$

$$(B) + H_2SO_4 + H_2O_2 \rightarrow (C) + \text{side products}$$
(dilute)

The sum of the total number of atoms in one molecule each of (*A*), (*B*) and (*C*) is _____.

(JEE Main 2020)

29. The number of P—O—P bonds in P_4O_{10} is _____.

30. Acidified potassium dichromate reacts with potassium iodide and oxidises it to I_2. What is the oxidation state of chromium in the products of the reaction?

SOLUTIONS

1. (b): On increasing the atomic number of lanthanide, there is regular decrease of ionic size due to poor shielding of 4*f* electrons (lanthanide contraction).

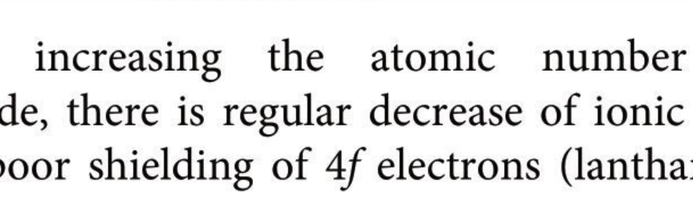
2. (d): One oxide turns lime water milky thus it can be CO_2 or SO_2. Oxide turns $CuSO_4$ (anhydrous) blue thus oxide is H_2O. Oxide is basic (pH = 9) thus it is of alkaline metal.

3. (d): $_{22}Ti = 3d^2\ 4s^2$, $Ti^{2+} = 3d^2$
$_{23}V = 3d^3\ 4s^2$, $V^{3+} = 3d^2$
$_{24}Cr = 3d^5\ 4s^1$, $Cr^{4+} = 3d^2$
$_{25}Mn = 3d^5\ 4s^2$, $Mn^{5+} = 3d^2$

4. (c): In higher oxidation state, a transition metal acts as an oxidizing agent.

5. (a): XeF_2 is a strong oxidising agent.

6. (d): The order of acidity is $H_3PO_2 > H_3PO_3 > H_3PO_4$



H_3PO_2 H_3PO_3 H_3PO_4

Reducing nature depends on no. of P—H bonds. More the no. of P—H bonds, more will be the reducing nature. Thus, H_3PO_2 is stronger reducing agent than H_3PO_3 while H_3PO_4 does not act as reducing agent at all.

H_3PO_2, H_3PO_3 and H_3PO_4 contain one, two and three ionisable hydrogen atoms (P—OH bonds) respectively. As P is sp^3 hybridised, therefore all are tetrahedral.

7. (d): Monoclinic sulphur is prepared by melting the rhombic sulphur in a dish and cooling it till a crust is formed.

8. (b):

Tetrahedral Manganate ion (green) — Tetrahedral Permanganate ion (purple)

In manganate and permanganate ions, π-bonding takes place by overlap of *p* -orbitals of oxygen with *d*-orbitals of manganese.

9. (d)

10. (a):

$$Cr_2O_7^{2-} + 6e^- \longrightarrow 2Cr^{3+}$$
$$[Sn^{2+} \longrightarrow Sn^{4+} + 2e^-] \times 3$$
$$Cr_2O_7^{2-} + 3Sn^{2+} \longrightarrow 3Sn^{4+} + 2Cr^{3+}$$

$\because$ 3 moles of Sn^{2+} ions reduce one mole of $K_2Cr_2O_7$

$\therefore$ 1 mole of Sn^{2+} ion reduce $\frac{1}{3}$ mole of $K_2Cr_2O_7$

11. (a)

12. (b):

$$\underset{\text{Urea}}{NH_2-\overset{\overset{O}{\|}}{C}-NH_2} + H_2O \longrightarrow \underset{(A)}{NH_2COONH_4}$$

$$\underset{(B)}{2NH_3 + CO_2} \longleftarrow$$

$$Cu^{2+}_{(aq)} + 4NH_3 \longrightarrow \underset{\text{(deep blue)}}{[Cu(NH_3)_4]^{2+}_{(aq)}}$$
(*C*)

13. (d): Cu^+ has stable configuration, $[Ar]3d^{10}$.

14. (a): The stability of interhalogen compounds decreases as the size of central atom decreases due to electronegativity difference. Hence, the stability of interhalogen compounds follows the order :

$$IF_3 > BrF_3 > ClF_3$$

15. (a)

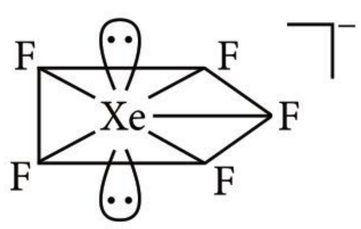
16. (b): La^{3+} $(4f^0)$, Gd^{3+} $(4f^7)$, Lu^{3+} $(4f^{14})$ — Colourless
Sm^{3+} $(4f^5)$ — Yellow coloured

17. (c) : NH_3 is distinctly basic due to the small size of the nitrogen atom. The lone pair of electrons is concentrated on a small region and hence, its electron releasing tendency is maximum.

18. (b) : The colour arise by charge transfer. In MnO_4^-, an electron is momentarily transferred from oxygen to the metal and thus oxygen changes from O^{2-} to O^- and Mn from (+7) to (+6).

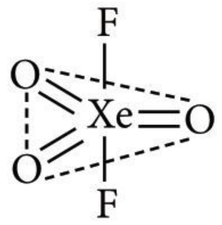
19. (a) : More the distance between nucleus and outer orbitals, lesser will be force of attraction on them. Distance between nucleus and 5*f* orbitals is more as compared to distance between 4*f* orbital and nucleus. So actinoids exhibit more number of oxidation states in general than the lanthanoids.

20. (a) :



$[XeF_5]^-$

Pentagonal bipyramidal
(Pentagonal planar shape)



$[XeO_3F_2]$

Trigonal bipyramidal

21. (a) : $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \xrightarrow[\text{(air)}]{\text{Heat}} 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

$Na_2CrO_4 \xrightarrow{H^+/NH_4Cl} (NH_4)_2Cr_2O_7 \xrightarrow{\text{Heat}}$

$4H_2O + N_2\uparrow + Cr_2O_3 \xrightarrow{Al} Cr + Al_2O_3$

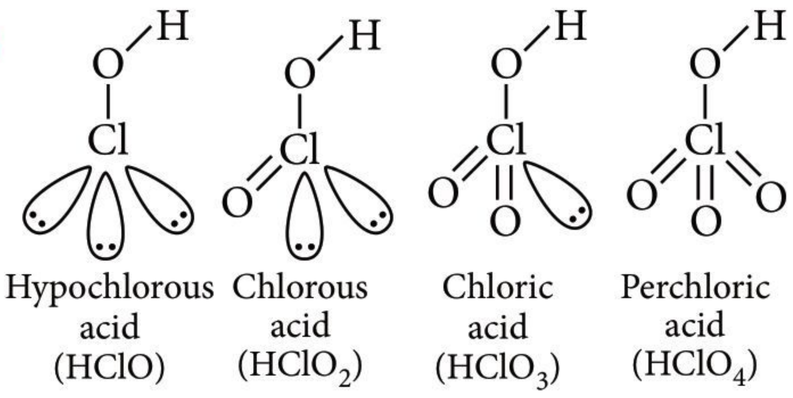
22. (c) : Mn^{3+} and Co^{3+} are stronger oxidizing agents because

(a) Mn^{2+} is stable than Mn^{3+} due to stable half filled d^5 configuration.

(b) In aqueous solution, Co^{2+} is more stable than Co^{3+}.

23. (a) : As the electronegativity of the central metal atom *M* in MCl_3 decreases down the group in nitrogen family, the tendency to attract lone pair of electrons from water molecule decreases. Hence, the ease of hydrolysis decreases from top to bottom.

24. (b) :



Hypochlorous acid ($HClO$) | Chlorous acid ($HClO_2$) | Chloric acid ($HClO_3$) | Perchloric acid ($HClO_4$)

In all these oxoacids, Cl is sp^3-hybridized.
Acid strength of oxoacids of the same halogen decreases with decrease in oxidation number of the halogen,

$\overset{+7}{HClO_4} > \overset{+5}{HClO_3} > \overset{+3}{HClO_2} > \overset{+1}{HClO}$

25. (b) : $La(OH)_3$ is most basic. Hence, (I) is wrong. (II) is correct due to lanthanoid contraction. (III) is correct because Ce^{4+} tends to change to stable Ce^{3+}.

26. (4)

27. (2.83) : Number of unpaired electrons in Ni^{2+} is 2.
Hence, the spin only magnetic moment

$= \sqrt{n(n+2)} = \sqrt{2(2+2)} = \sqrt{8} = 2.83$ B.M.

28. (18) : $NaCl + K_2Cr_2O_7 + H_2SO_4$ (conc.) $\rightarrow \underset{(A)}{CrO_2Cl_2}$ + side products

$\underset{(A)}{CrO_2Cl_2} + NaOH \rightarrow \underset{(B)}{Na_2CrO_4}$ + side products

$\underset{(B)}{Na_2CrO_4} + \underset{\text{(dilute)}}{H_2SO_4} + H_2O_2 \rightarrow \underset{(C)}{CrO_5}$ + side products

The sum of total number of atoms in one molecule each of (*A*), (*B*) and (*C*) is 5 + 7 + 6 = 18.

29. (6)

30. (3) : During the reaction $K_2Cr_2O_7$ is converted to $Cr_2(SO_4)_3$

$K_2Cr_2O_7 + 7H_2SO_4 + 6KI \rightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3I_2$

In $Cr_2(SO_4)_3$, O.S. of Cr is +3.

LEARN FAST

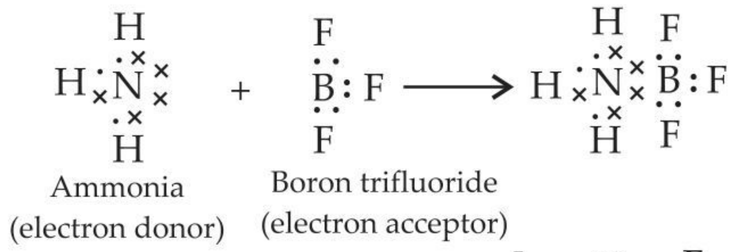
Some Important Halides of Group 13 and Group 14 Elements

TYPES OF HALIDES

- **Ionic or salt-like halides :** Metals having relatively low ionisation energies, form halides which are ionic in nature. Some of the metals, in their lower oxidation states, also give essentially ionic halides. Due to high lattice energies, almost all the metallic fluorides are ionic substances.
  - AlF_3 is essentially ionic, $AlCl_3$ dimer has intermediate character.
- **Covalent or acidic halides :** These halides are given by non-metals, as well as by metals with high charge/size ratio. Examples are CCl_4, NF_3, PCl_3, etc.
- **Complex halides :** The halides, whose central atom has vacant *p*-orbitals and/or vacant *d*-orbitals can accommodate lone pairs of electrons donated by the halide ions and can thus form complex halide ions. Examples are,
  AlF_6^{3-}, $GaCl_4^-$, $TiBr_4^-$, SiF_6^{2-}, $SnCl_4^{2-}$, PCl_6^-, SbF_5^{2-}, etc.
  F^- ion forms stable complex halide ions with smaller cations like B^{3+}, Al^{3+}, Si^{4+} because of strong electrostatic force and high energies of the resulting bonds.

HALIDES OF GROUP 13 ELEMENTS (BORON FAMILY)

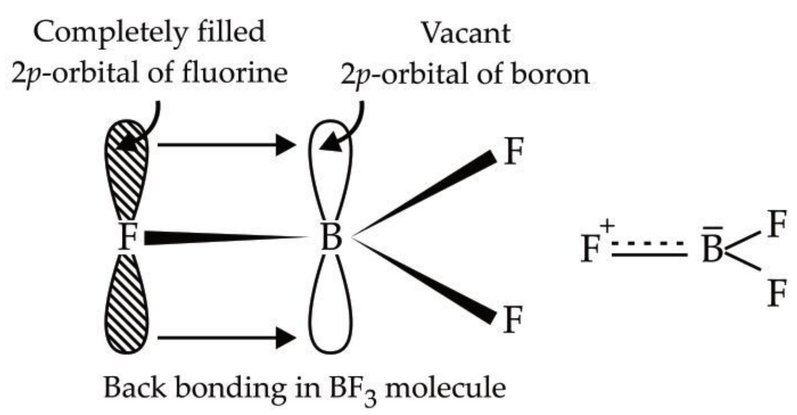
- All the elements of group-13 form trihalides (MX_3) (except TlI_3, which is not known) by direct combination with halogen.
  $2M_{(s)} + 3X_{2(g)} \xrightarrow{\Delta} 2MX_3$ (X = F, Cl, Br or I)
- All the trihalides of group 13 elements are known except Tl(III) iodide.
- Due to small size and high electronegativity of boron, all boron halides are covalent in nature and act as Lewis acids. These halides exist as monomeric molecules having planar triangular geometry (sp^2 hybridisation).
- All boron trihalides except BF_3, are hydrolysed to boric acid.
  $BX_3 \cdot 3H_2O \longrightarrow B(OH)_3 + 3HX$; ($X$ = Cl, Br, I)
  However, BF_3 forms an addition product with water.
  $BF_3 + H_2O \rightleftharpoons H^+[BF_3OH]^- \xrightleftharpoons{H_2O} H_3O^+[BF_3OH]^-$
  Being a Lewis acid and having less tendency for hydrolysis, BF_3 is used as a catalyst in organic reactions *e.g.*, Friedel–Crafts reaction.
- Boron atom, in BX_3, has six electrons in the outermost orbit and thus, it can accept a pair of electrons from a donor molecule like NH_3 to complete its octet. Hence, boron halides act as very efficient Lewis acids.



or $H_3N \rightarrow BF_3$

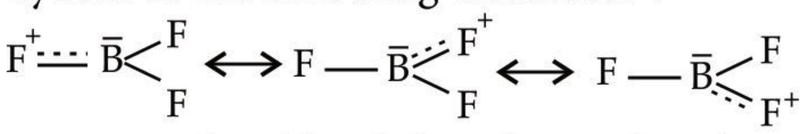
Similarly, R_2O: + $BF_3 \longrightarrow [R_2O \rightarrow BF_3]$

- The relative Lewis acid characters of boron trihalides are found to obey the order :
  $BI_3 > BBr_3 > BCl_3 > BF_3$
  - This anomalous behaviour of BF_3 has been explained on the basis of the relative tendency of the halogen atom to back-donate its unutilised electrons to the vacant *p*-orbitals of boron atom. In boron trifluroide, each fluorine has completely filled unutilised 2*p*-orbitals while boron has a vacant 2*p*-orbital. Now since both of these orbitals belong to same energy level (2*p*), they can overlap effectively as a result of which fluorine electrons are transferred into the vacant 2*p*-orbital of boron resulting in the formation of an additional $p\pi$-$p\pi$ bond. This type of bond formation is known as **back bonding** or **back donation.**



Back bonding in BF_3 molecule

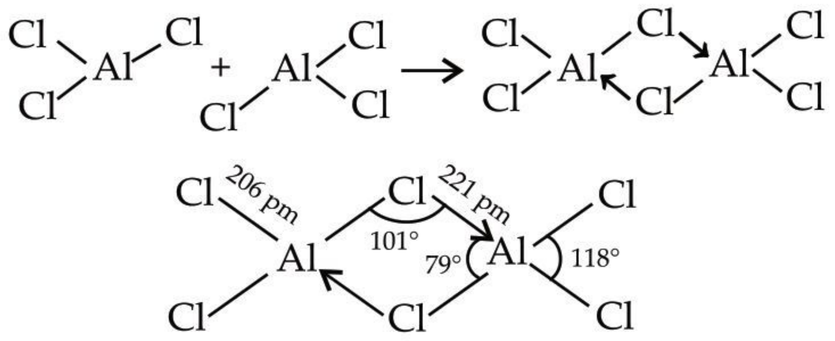
- Thus the B—F bond has some double bond character. Back bonding may take place between boron and any of the three fluorine atoms and thus boron trifluoride is regarded as a resonance hybrid of the following structures :



- As a result of back bonding, the electron deficiency of boron is reduced and hence Lewis acidic nature is decreased. The tendency for the formation of back bonding ($p\pi$-$p\pi$ bond) is maximum in BF_3 and decreases very rapidly from BF_3 to BI_3. Thus, BI_3, BBr_3 and BCl_3 are stronger Lewis acids than BF_3.
- Lewis acid character of halides of the group 13 elements decreases in the order :

$$B > Al > Ga > In$$

- Boron halides form complex halides of the type, $[BF_4^-]$, in which boron atom extends its coordination number to four by utilising empty *p*-orbital. It cannot extend its coordination number beyond four due to non-availability of *d*-orbitals. However, the other trihalides of this group form complex halides of the type $(AlF_6)^{3-}$, $(GaCl_6)^{3-}$ and $(InCl_6)^{3-}$ etc., where the central atom extends its coordination number to six by the use of *d*-orbitals.
- The fluorides of Al, Ga, In and Tl are ionic and have high melting points.
- Other halides of Al, Ga, In and Tl are largely covalent in anhydrous state and possess low melting points. These halides do not show backbonding because of increase in the size of the element. However, they make use of vacant *p*-orbitals by coordinate bond *i.e.*, metal atoms complete their octet by forming dimers. Thus, aluminium chloride, aluminium bromide and indium iodide exist as dimers both in the vapour state and in the non-polar solvents.



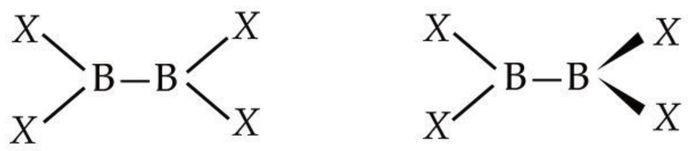
Dimer structure of $AlCl_3$

- The dimer structure for Al_2Cl_6 is supported by the following facts :
  - Vapour density of aluminium chloride measured at 400°C corresponds to the formula Al_2Cl_6.
  - Bond distance between Al—Cl bond forming bridge is greater (2.21 Å) than the distance between Al—Cl bond present in the end (2.06 Å).
  - The dimeric structure disappears when the halides are dissolved in water. This is due to high heat of hydration which splits the dimeric structure into $[M(H_2O)_6]^{3+}$ and X^- ions and the solution becomes good conductor of electricity.

$$Al_2Cl_6 + 12H_2O \longrightarrow 2[Al(H_2O)_6]^{3+} + 6Cl^-$$

Therefore, Al_2Cl_6 is ionic in water.

- In addition to trihalides, these elements form divalent as well as monovalent halides. Boron also forms B_2X_4 which is planar in solid state and non-eclipsed in liquid or vapour state.



(Planar structure) (Non-eclipsed structure)

- Monohalides (*MX*) are formed in gaseous state and they are very unstable halides. They are covalent in nature and covalent character decreases from B to Tl, and thallium halides are ionic in nature.

BORON HALIDES

- Boron forms all the trihalides (BX_3), where X = F, Cl, Br or I.

Preparation

- By direct combination : Under suitable conditions, boron reacts with halogens to form trihalides (BX_3).

$$2B + 3X_2 \longrightarrow 2BX_3$$

- BF_3, an industrial catalyst may be prepared as follows :

$$3CaF_2 + B_2O_3 + 3H_2SO_4 \longrightarrow 2BF_3 + 3CaSO_4 + 3H_2O$$

- Other boron trihalides (except BF_3) are prepared by following reaction :

$$B_2O_3 + 3C + 3X_2 \longrightarrow 2BX_3 + 3CO \ (X_2 = Cl_2, Br_2, I_2)$$

MONTHLY TEST DRIVE CLASS XII ANSWER KEY

1.	(a)	2.	(c)	3.	(b)	4.	(a)	5.	(c)
6.	(c)	7.	(b)	8.	(c)	9.	(b)	10.	(a)
11.	(d)	12.	(d)	13.	(d)	14.	(a)	15.	(b)
16.	(b)	17.	(c)	18.	(c)	19.	(b)	20.	(b,c)
21.	(a,b)	22.	(a,b,c,d)	23.	(a,c,d)	24.	(2)	25.	(7)
26.	(51)	27.	(b)	28.	(b)	29.	(a)	30.	(b)

Properties

- Due to small size of B^{3+}, these halides are covalent. They are non-electrolytes and do not conduct electricity in liquid state.
- BF_3 is a colourless gas, BCl_3 is a colourless fuming liquid (b.pt. = 13°C), while BI_3 is a white fusible solid (m.pt. = 310°C).
- Melting and boiling points of halides of boron (BX_3) decrease in the order :

  $BI_3 > BBr_3 > BCl_3 > BF_3$
- Boron halides (except BF_3) are readily hydrolysed in water.
- Aqueous non-oxidising acids like HF, HCl and HI do not react even with colloidal boron but anhydrous HF reacts exothermically and forms BF_3.

ALUMINIUM TRIHALIDES

Preparation

- AlF_3 is made by treating Al_2O_3 with HF gas at 700°C and the other trihalides are made by the direct exothermic combination of the elements.

Properties of crystalline AlX_3

- AlF_3 differs from the other trihalides of Al in being non-volatile, insoluble, and in having a much greater heat of formation.

Property	AlF_3	$AlCl_3$	$AlBr_3$	AlI_3
m.pt./°C	1290	192.4	97.8	189.4
Sublimation pt. (1 atm)/°C	1272	180	256	382
ΔH_f°/kJ mol^{-1}	1498	707	527	310

$4AlCl_3 + 6POCl_3 \longrightarrow [Al(OPCl_3)_6]^{3+} + 3[AlCl_4]^-$

$2Al_2I_6 + 12POCl_3 \rightleftharpoons 4AlCl_3 + 12POCl_2I$

$AlCl_3 + 3LiY \longrightarrow 3LiCl + AlY_3$

(Y = R, NR_2, N = CR_2)

$AlCl_3 + 4LiY \longrightarrow 3LiCl + LiAlY_4$

(Y = R, NR_2, N = CR_2, H)

Similarly, $NaOR$ reacts to give $Al(OR)_3$ and $NaAl(OR)_4$. $AlCl_3$ also converts non-metal fluorides into the corresponding chlorides, *e.g.*,

$BF_3 + AlCl_3 \longrightarrow AlF_3 + BCl_3$

ALUMINIUM CHLORIDE, $AlCl_3$

Preparation

- **Anhydrous aluminium chloride :** It is prepared by passing dry HCl gas or chlorine gas over heated aluminium turnings in the absence of air.

$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

$2Al + 3Cl_2 \longrightarrow 2AlCl_3$

- A mixture of alumina and carbon on heating in a current of chlorine produces anhydrous $AlCl_3$.

$$Al_2O_3 + 3C + 3Cl_2 \xrightarrow{1000°C} \underset{\text{Vapours}}{2AlCl_3} + 3CO$$

$\downarrow$ cooled

Solid anhydrous aluminium chloride

- **Hydrated aluminium chloride :** $AlCl_3 \cdot 6H_2O$ is ionic and formed when aluminium metal or aluminium hydroxide is dissolved in dilute hydrochloric acid.

$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

$Al(OH)_3 + 3HCl \longrightarrow AlCl_3 + 3H_2O$

Chemical nature

- Anhydrous aluminium chloride fumes in moist air due to the evolution of HCl.

$Al_2Cl_6 + 6H_2O \longrightarrow 2Al(OH)_3 + 6HCl$

In water, it converts into hydrated aluminium chloride which is ionic in nature.

$Al_2Cl_6 + 12H_2O \longrightarrow 2AlCl_3 \cdot 6H_2O$

- Anhydrous aluminium chloride forms an addition product with ammonia gas.

$Al_2Cl_6 + 12NH_3 \longrightarrow 2[AlCl_3 \cdot 6NH_3]$

- When ammonium hydroxide NH_4OH is added to the solution of aluminium chloride, a gelatinous precipitate of aluminium hydroxide appears which does not dissolve in excess of NH_4OH.

$$AlCl_3 + 3NH_4OH \longrightarrow \underset{\text{gelatinous ppt.}}{Al(OH)_3\downarrow} + 3NH_4Cl$$

- When sodium hydroxide (NaOH) is added to the solution of aluminium chloride drop by drop, a white gelatinous precipitate forms which dissolves in excess of sodium hydroxide forming sodium meta aluminate.

$$AlCl_3 + 3NaOH \longrightarrow \underset{\text{gelatinous ppt.}}{Al(OH)_3\downarrow} + 3NaCl$$

$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$

HALIDES OF GROUP 14 ELEMENTS (CARBON FAMILY)

- Group-14 elements form covalent tetrahalides of the type MX_4 having tetrahedral nature, except $PbBr_4$ and PbI_4. The non-existence of $PbBr_4$ and PbI_4 is due to the fact that Pb^{4+} ion is a strong oxidising agent while Br^- and I^- ions are strongly reducing agents. Thus, Pb^{4+} ion cannot survive in presence of Br^- or I^- ion and is reduced to Pb^{2+} ion.

$Pb^{4+} + 2Br^- \longrightarrow Pb^{2+} + Br_2$

- Except carbon, all other elements of group-14 also form dihalides such as MX_2. The stability of divalent halides increases down the group in accordance with inert pair effect.
- The order of thermal stability of tetrahalides is :

  $CX_4 > SiX_4 > GeX_4 > SnX_4 > PbX_4$

  - The thermal stability and volatility of tetrahalides with a common central atom decreases with the increase in molecular weight of the tetrahalides *i.e.*,

    $MF_4 > MCl_4 > MBr_4 > MI_4$

  i.e., $CF_4 > CCl_4 > CBr_4 > CI_4$

  This is due to the decrease in the C — X bond energies from C — F to C — I.
- The tetrahalides (except carbon halides) are readily hydrolysed by water. The trend towards hydrolysis decreases down the group. Thus, silicon tetrachloride $SiCl_4$, fumes in moist air liberating hydrogen chloride.

  $$SiCl_4 + 4H_2O \longrightarrow \underset{\text{Silicic acid}}{Si(OH)_4} + 4HCl$$
- Since carbon has no *d*-orbital, it cannot extend its coordination number beyond four, so its halides are not attacked (hydrolysed) by water. On the other hand, silicon and other elements of this group have vacant *d*-orbitals to which water molecules can coordinate and hence, their halides are hydrolysed by water.
- Due to the presence of vacant *d*-orbitals Si, Ge, Sn and Pb also form hexahaloanions of type $[MX_6]^{2-}$, in which atom is hexacoordinated (M = Si, Ge, Sn or Pb).
- The tetrahalides of carbon, on the other hand, do not form any complex ion because carbon has no *d*-orbital to accommodate any more electrons from the ligand (donor) like X^-.

HALIDES OF TIN

- **Stannous fluoride, SnF_2 :** It is obtained by reacting SnO with HF.

  $$SnO + 2HF \longrightarrow SnF_2 + H_2O$$
- **Stannic fluoride, SnF_4 :** It can be prepared by gently heating $SnCl_4$ with excess of HF, until no more HCl is liberated.

  $$SnCl_4 + 4HF \longrightarrow SnF_4 + 4HCl$$

STANNOUS CHLORIDE, $SnCl_2$

Preparation

- Tin reacts with hot concentrated HCl to give hydrated $SnCl_2 \cdot 2H_2O$.
- Anhydrous $SnCl_2$ is formed when dry HCl gas is heated over tin or by heating a mixture of Sn and calculated quantity of mercuric chloride.

  $$Sn + 2HCl_{(gas)} \longrightarrow SnCl_2 + H_2$$

  $$Sn + HgCl_2 \longrightarrow SnCl_2 + Hg$$
- Anhydrous salt cannot be obtained by heating the hydrated salts. On heating hydrolysis is noticed with the formation of a white solid (tin hydroxy chloride).

  $$SnCl_2 \cdot 2H_2O \longrightarrow Sn(OH)Cl + H_2O + HCl$$

Physical properties

- It is a white crystalline solid, soluble in water, alcohol and ether.
- In water, it is hydrolysed readily. But, in presence of HCl, hydrolysis is reversed.

Chemical properties

- Reaction with alkalies : It reacts with NaOH, forms a white precipitate which dissolves in excess of alkali.

  $$SnCl_2 + 2NaOH \longrightarrow \underset{\text{Stannous hydroxide}}{Sn(OH)_2\downarrow} + 2NaCl$$

  $$Sn(OH)_2 + 2NaOH \longrightarrow \underset{\text{Sodium stannite}}{Na_2SnO_2} + 2H_2O$$
- Reaction with H_2S : It reacts with H_2S to give a dark brown ppt. of SnS. This precipitate is soluble in yellow ammonium sulphide, $(NH_4)_2S_2$, due to the formation of ammonium thiostannate $(NH_4)_2[SnS_3]$.

  $$SnCl_2 + H_2S \longrightarrow \underset{\text{dark brown ppt.}}{SnS\downarrow} + 2HCl$$

  $$SnS + \underset{\substack{\text{Yellow ammonium}\\\text{sulphide}}}{(NH_4)_2S_2} \longrightarrow \underset{\substack{\text{Ammonium}\\\text{thiostannate}}}{(NH_4)_2SnS_3}$$
- Reducing properties : $SnCl_2$ acts as a strong reducing agent.
  - $SnCl_2$ reduces $HgCl_2$ to Hg_2Cl_2 (white ppt.) and finally to metallic Hg.

    $2Hg^{2+} + Sn^{2+} \longrightarrow Hg_2^{2+} + Sn^{4+}$

    $Hg_2^{2+} + Sn^{2+} \longrightarrow 2Hg\downarrow + Sn^{4+}$
  - It reduces ferric salts to ferrous salts and cupric salts to cuprous salts.

    $2Fe^{3+} + Sn^{2+} \longrightarrow 2Fe^{2+} + Sn^{4+}$

    $2Cu^{2+} + Sn^{2+} \longrightarrow 2Cu^{+} + Sn^{4+}$

- It reduces $-NO_2$ group is to $-NH_2$ group.

$$3SnCl_2 + \underset{\text{Nitrobenzene}}{C_6H_5NO_2} + 6HCl \longrightarrow \underset{\text{Aniline}}{3SnCl_4 + C_6H_5NH_2} + 2H_2O$$

- It decolourises iodine.

$$SnCl_2 + 2HCl + I_2 \longrightarrow SnCl_4 + 2HI$$

- It reduces gold chloride to metallic gold sol (Purple of Cassius).

$$3SnCl_2 + 2AuCl_3 \longrightarrow \underset{\text{Colloidal gold}}{2Au} + 3SnCl_4$$

STANNIC CHLORIDE, $SnCl_4$

- $SnCl_4 \cdot 5H_2O$, is known as "butter of tin" or "oxymuriate of tin".

  $SnCl_4$ is obtained by :

  - Hydrolysis :

$$SnCl_4 + 4H_2O \longrightarrow \underset{\text{Stannic hydroxide}}{Sn(OH)_4} + 4HCl$$

  - Reaction with conc. HCl :

$$SnCl_4 + 2HCl \longrightarrow \underset{\text{Chlorostannic acid}}{H_2SnCl_6}$$

  - Reaction with NH_4Cl :

$$SnCl_4 + 2NH_4Cl \longrightarrow \underset{\substack{\text{Ammonium chlorostannate}\\ \text{(pink, used as mordant in}\\ \text{dyeing under the name pink salt)}}}{(NH_4)_2SnCl_6}$$

HALIDES OF LEAD

LEAD DIFLUORIDE, PbF_2

Preparation

- It is formed :
  - as a white ppt. when a soluble fluoride is added to a lead salt solution.
  - by the action of HF on PbO or $Pb(CO_3)_2$.

Properties

- It is a white powder with melting point 818°C.

LEAD TETRAFLUORIDE, PbF_4

Preparation

- Passing F_2 over PbF_2 above 250°C.

$$PbF_2 + F_2 \xrightarrow{250°C} PbF_4$$

- By dissolving red lead or freshly prepared PbO_2 in BrF_3.

$$3PbO_2 + 4BrF_3 \longrightarrow 3PbF_4 + 2Br_2 + 3O_2$$

LEAD CHLORIDE OR PLUMBOUS CHLORIDE, $PbCl_2$

Preparation

- By adding HCl to aqueous solution of lead nitrate.

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2\downarrow + 2HNO_3$$

Properties

- It is a white crystalline solid, slightly soluble in cold water but completely soluble in hot water.
- It is fairly soluble in concentrated hydrochloric acid forming chloroplumbic acid.

$$PbCl_2 + 2HCl \longrightarrow H_2PbCl_4$$

LEAD TETRACHLORIDE OR PLUMBIC CHLORIDE, $PbCl_4$

Preparation

- It is prepared by dissolving lead dioxide in a well-cooled hydrochloric acid.

$$PbO_2 + 4HCl \rightleftharpoons PbCl_4 + 2H_2O$$

Properties

- It is only slightly stable.

$$PbCl_4 \longrightarrow PbCl_2 + Cl_2$$

- It is decomposed by excess of water.
- It forms a double chloride with ammonium chloride known as ammoniumplumbichloride or ammoniumchloroplumbate, $(NH_4)_2PbCl_6$. Although the later compound is fairly stable, when treated with sulphuric acid it decomposes back to lead tetrachloride.

$$[(NH_4)_2PbCl_6] + H_2SO_4 \longrightarrow (NH_4)_2SO_4 + PbCl_4 + 2HCl$$

LEAD DIIODIDE, PbI_2

Preparation

- by dissolving lead, its oxide or carbonate in HI.
- by adding a soluble iodide to a lead salt solution.

Properties

- It forms golden-yellow crystals with melting point 402°C and boiling point 872°C.
- On heating it first turns brick red and then brown red but regains its original colour on cooling.
- It dissolves in a large excess of KI forming $K[PbI_3]$ which is decomposed on dilution with water depositing PbI_2 again.

CBSE warm-up!

CLASS-XII

TERM-I OBJECTIVE TYPE QUESTIONS*

Practice Paper 2021

Time allowed : 90 minutes
Maximum marks : 35

GENERAL INSTRUCTIONS

1. *The Question Paper contains three sections.*
2. *Section A has 25 questions. Attempt any 20 questions.*
3. *Section B has 24 questions. Attempt any 20 questions.*
4. *Section C has 6 questions. Attempt any 5 questions.*
5. *All questions carry equal marks.*
6. *There is no negative marking.*

- **The Solid State**
- **Solutions**
- **The *p*-Block Elements**
- **Haloalkanes and Haloarenes**
- **Alcohols, Phenols and Ethers**
- **Biomolecules**

SECTION - A

This section consists of 25 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, ONLY first 20 will be considered for evaluation.

1. For a binary ideal liquid solution, the total pressure of the solution is given as :
(a) $p_{total} = p_A^\circ + (p_A^\circ - p_B^\circ)\, x_A$
(b) $p_{total} = p_B^\circ + (p_A^\circ - p_B^\circ)\, x_A$
(c) $p_{total} = p_B^\circ + (p_B^\circ - p_A^\circ)\, x_A$
(d) $p_{total} = p_A^\circ + (p_B^\circ - p_A^\circ)\, x_A$

2. A compound formed by elements *A* and *B* crystallises in the cubic structure where *A* atoms are at the corners of a cube and *B* atoms are at the face centre. The formula of the compound is :
(a) AB_3 (b) A_2B (c) AB_2 (d) A_2B_3

3. Phenol with dilute HNO_3 gives
(a) *meta*- and *para*-nitrophenol
(b) *ortho*- and *para*-nitrophenol
(c) trinitrophenol
(d) ortho- and meta-nitrophenol.

4. The main structural feature of proteins is
(a) ester linkage (b) ether linkage
(c) peptide linkage (d) all of these.

5. An aromatic ether is not cleaved by HI even at 525 K. The compound is
(a) $C_6H_5OCH_3$
(b) $C_6H_5O - C_6H_4(CH_3)$
(c) $C_6H_5OC_3H_7$ (d) tetrahydrofuran.

6. The reaction, $C_6H_5N_2Cl \xrightarrow{Cu_2Cl_2/HCl} C_6H_5Cl + N_2$ is called
(a) Etard's reaction
(b) Sandmeyer's reaction
(c) Wurtz-Fittig reaction
(d) Perkin's reaction.

7. The geometry of $XeOF_2$ is
(a) pyramidal (b) T-shaped
(c) octahedral (d) tetrahedral.

** Practice paper for CBSE Exam Term- I as per the pattern issued by CBSE.*

8. On heating ammonium dichromate, the gas evolved is
(a) oxygen (b) ammonia
(c) nitric acid (d) nitrogen.

9. Glucose when treated with CH_3OH in presence of dry HCl gas gives α- and β-methylglucosides because it contains
(a) an aldehydic group (b) a $-CH_2OH$ group
(c) a ring structure (d) five –OH groups.

10. A 5% solution (by mass) of cane sugar in water has freezing point of 271 K. Calculate the freezing point of 5% glucose in water if freezing point of pure water is 273.15 K.
(a) 4.085 K (b) 8.205 K
(c) 269.07 K (d) 274.08 K

11. In which pair most efficient packing is present?
(a) *hcp* and *bcc* (b) *hcp* and *ccp*
(c) *bcc* and *ccp*
(d) *bcc* and simple cubic cell

12. Replacement of Cl of chlorobenzene to give phenol requires drastic conditions but chlorine of 2,4-dinitrochlorobenzene is readily replaced because
(a) NO_2 makes the ring electron rich at *ortho* and *para* positions
(b) NO_2 withdraws electrons at *meta*-position
(c) NO_2 donates electrons at *m*-position
(d) NO_2 withdraws electrons at *ortho* and *para* positions.

13. An element occurs in the *bcc* structure with a cell edge length of 288 pm. The density of the element is 7.2 g cm^{-3}. How many atoms of the elements does 208 g of the element contain?
(a) 24.16×10^{25} (b) 24.16×10^{23}
(c) 24.16×10^{24} (d) 24.16×10^{26}

14. Which is not a characteristic of alcohols?
(a) They are lighter than water.
(b) Their boiling points rise fairly uniformly with rising molecular weight.
(c) Lower members are insoluble in water and organic solvents but the solubility regularly increases with molecular mass.
(d) Lower members have a pleasant smell and burning taste, higher members are colourless and tasteless.

15. Which one of the following oxides of nitrogen is blue solid?
(a) NO (b) N_2O_3 (c) N_2O (d) N_2O_5

16. Concentrated H_2SO_4 reacts with PCl_5 to produce
(a) SO_2 (b) H_3PO_4
(c) SO_2Cl_2 (d) $SOCl_2$

17. Osmotic pressure of urea solution at 10°C is 500 mm. The solution is diluted with temperature raised to 25°C till its osmotic pressure becomes 131.6 mm. The solution is diluted
(a) 3 times (b) 3.5 times
(c) 4 times (d) 3.8 times.

18. Glucose molecule reacts with *X* number of molecules of phenylhydrazine to yield osazone. The value of *X* is
(a) three (b) two (c) one (d) four.

19. The order of reactivities of the following alkyl halides for a S_N2 reaction is
(a) *R*F > *R*Cl > *R*Br > *R*I (b) *R*F > *R*Br > *R*Cl > *R*I
(c) *R*Cl > *R*Br > *R*F > *R*I (d) *R*I > *R*Br > *R*Cl > *R*F.

20. The most unsymmetrical system is
(a) cubic (b) hexagonal
(c) triclinic (d) orthorhombic.

21. The number of amino acids found in proteins that a human body can synthesize is
(a) 20 (b) 10 (c) 5 (d) 14

22. Bleaching powder is obtained by the action of chlorine gas and
(a) dilute solution of $Ca(OH)_2$
(b) concentrated solution of $Ca(OH)_2$
(c) dry CaO
(d) dry slaked lime.

23. During depression in freezing point of a solution the following are in equilibrium
(a) liquid solvent, solid solvent
(b) liquid solvent, solid solute
(c) liquid solute, solid solute
(d) liquid solute, solid solvent.

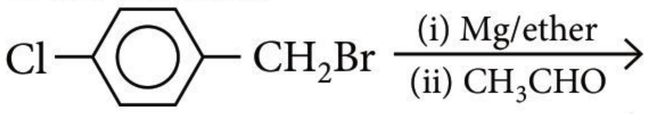
24. Which of the following cannot be prepared by using Williamson's synthesis?
(a) Methoxybenzene
(b) Benzyl-*p*-nitrophenyl ether
(c) Methyl-*tert*-butyl ether
(d) Di-*tert* butyl ether

25. Which of the following statements about ribose is incorrect?
(a) It is a polyhydroxy compound.
(b) It is an aldehyde sugar.
(c) It has six carbon atoms.
(d) It exhibits optical activity.

SECTION - B

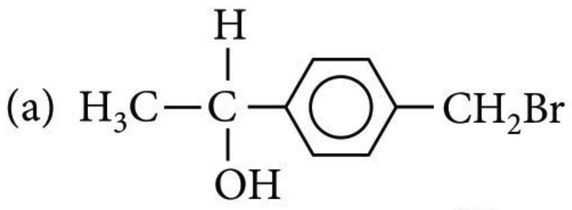
This section consists of 24 multiple choice questions with overall choice to attempt any 20 questions. In case more than desirable number of questions are attempted, ONLY first 20 will be considered for evaluation.

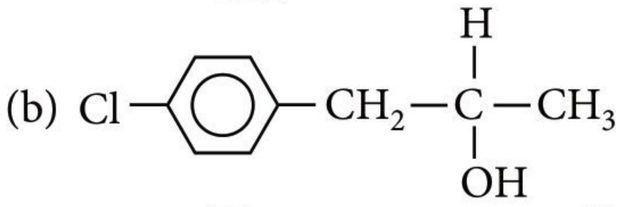
26. In the reaction,

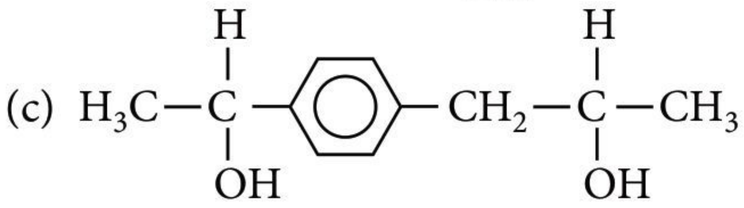


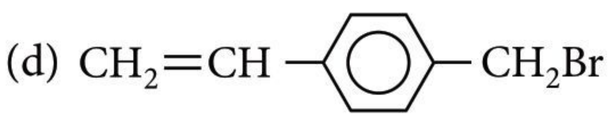
A(after hydrolysis)

The product A is

(a) 

(b) 

(c) 

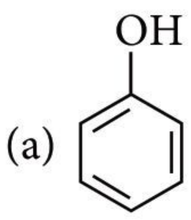
(d) 

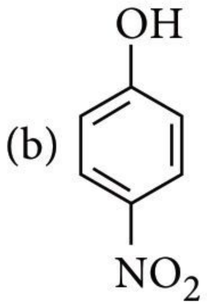
27. The pH value of a solution at which a polar amino acid does not migrate under the influence of an electric field is called

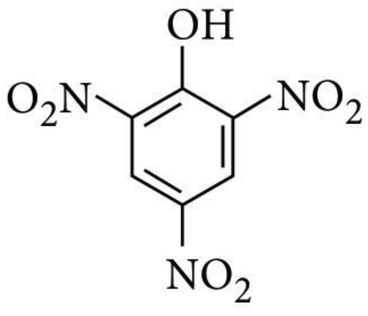
(a) isoelectronic point (b) isoelectric point

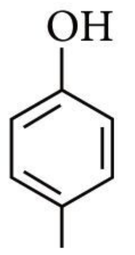
(c) neutralisation point (d) none of these.

28. Which one is the most acidic compound?

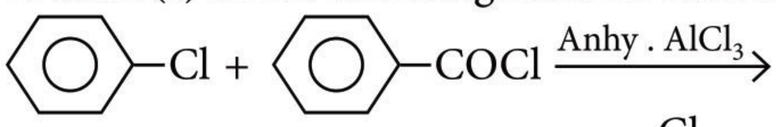
(a) 

(b) 

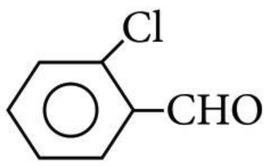
(c) 

(d) 

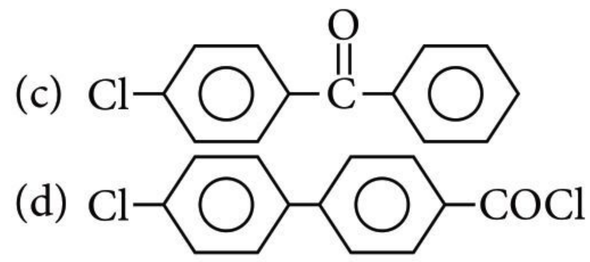
29. Product(s) of the following reaction can be



(a) 

(b) 

(c)

(d) 

30. Consider the reaction,

$CH_3CH_2CH_2Br + NaCN \longrightarrow CH_3CH_2CH_2CN + NaBr$

This reaction will be the fastest in

(a) ethanol

(b) methanol

(c) N, N'-dimethylformamide (DMF)

(d) water.

31. A compound with molecular mass 180 is acylated with CH_3COCl to get a compound with molecular mass 390. The number of amino groups present per molecule of the former compound is

(a) 5 (b) 4 (c) 6 (d) 2

32. A hard, crystalline solid with a high melting point does not conduct electricity in any phase. This solid is most likely

(a) an ionic solid (b) a metallic solid

(c) a molecular solid

(d) a network covalent solid.

33. A maxima or minima obtained in the temperature, composition curve of a mixture of two liquids indicates

(a) an azeotropic mixture

(b) an eutectic formation

(c) that the liquids are immiscible with one another

(d) that the liquids are partially miscible at the maximum or minimum.

34. Consider the following alkyl halides :

I. $(CH_3)_3CBr$ II. CH_3Br

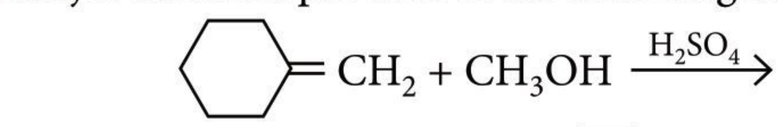
III. C_2H_5Br IV. $CH_3CHBrCH_3$

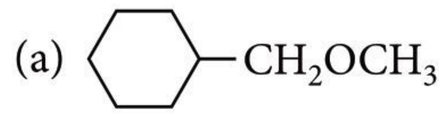
Arrange these alkyl halides in decreasing order of reactivity in Williamson reaction.

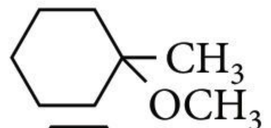
(a) I > IV > III > II (b) I > II > III > IV

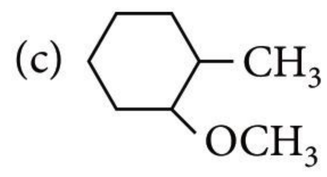
(c) IV > III > II > I (d) II > III > IV > I

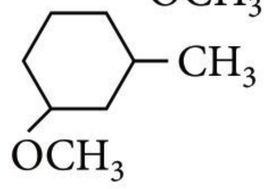
35. Major addition product of the following reaction is



(a) 

(b) 

(c) 

(d) 

36. If sphere of radius '*r*' are arranged in a *ccp* fashion (*ABCABC*...), then the vertical distance between any two consecutive *A* layers is

(a) $4r\sqrt{\frac{2}{3}}$ (b) $4r\sqrt{\frac{3}{2}}$ (c) $6r$ (d) $r\sqrt{6}$

37. Which of the following statements is incorrect regarding the structure of the ClO_2 molecule?

(a) The ClO_2 molecule is angular with O—Cl—O bond angle being 118°.
(b) The two Cl—O bonds lengths are equal.
(c) Both Cl—O bond lengths are greater than expected for a single Cl—O bond.
(d) Both Cl—O bond lengths are shorter than expected for a single Cl—O bond.

38. The correct order of solubility in water for He, Ne, Ar, Kr, Xe is

(a) He > Ne > Ar > Kr > Xe
(b) Xe > Kr > Ar > Ne > He
(c) Ne > Ar > Kr > He > Xe
(d) Ar > Ne > He > Kr > Xe

39. The Henry's law constant for the solubility of N_2 gas in water at 298 K is 1.0×10^5 atm. The mole fraction of N_2 in air is 0.8. The number of moles of N_2 from air dissolved in 10 moles of water at 298 K and 5 atm pressure is

(a) 4.0×10^{-4} (b) 4.0×10^{-5}
(c) 5.0×10^{-4} (d) 4.0×10^{-6}

40. Oxygen is more electronegative than sulphur. Yet H_2S is acidic while H_2O is neutral. This is because

(a) water is a highly associated compound
(b) molecular mass of H_2S is more than that of H_2O
(c) H_2S is gaseous under ordinary conditions while H_2O is a liquid
(d) H — S bond is weaker than H — O bond.

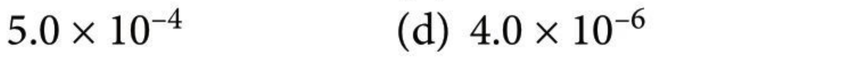
41. Find out (*Z*) in the following reaction sequence :

$$X \xrightarrow[\text{conc. } H_2SO_4]{413\text{ K}} Y \xrightarrow[\text{under pressure}]{\text{dil. } H_2SO_4/\Delta} Z$$

where, (*X*) is ethanol in excess

(a) C_2H_5OH (b) $C_2H_5OC_2H_5$
(c) $C_2H_5OSO_3H$ (d) $CH_2 = CH_2$

42. Which reaction is faster (i) or (ii) and what is its mechanism?

(i)  $+ CH_3O^-Na^+ \xrightarrow{DMF}$ $+ Br^-$

(ii) $+ CH_3S^-Na^+ \xrightarrow{DMF}$ $+ Br^-$

(a) Reaction (i), S_N1 (b) Reaction (ii), S_N2
(c) Reaction (ii), S_N1 (d) Reaction (i), S_N2

43. A metal crystallises into two cubic phases, face-centred cubic (*fcc*) and body-centred cubic (*bcc*) whose unit cell lengths are 3.5 Å and 3.0 Å, respectively. Calculate the ratio of densities of *fcc* to *bcc*.

(a) 1.259 (b) 1.871 (c) 2.112 (d) 0.115

44. Brown colour of HNO_3 can be removed by

(a) adding Mg powder (b) boiling the acid
(c) passing NH_3 through acid
(d) passing air through warm acid.

45. **Given below are two statements labelled as Assertion (A) and Reason (R).**

Assertion : An ideal solution obeys Raoult's law.

Reason : In an ideal solution, solute-solute as well as solvent-solvent interactions are similar to solute-solvent interactions.

Select the most appropriate answer from the options given below :

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

46. **Given below are two statements labelled as Assertion (A) and Reason (R)**

Assertion : S_N2 reaction of CH_3 — Br is faster in DMSO than in H_2O.

Reason : DMSO has greater capability to solvate nucleophile.

Select the most appropriate answer from the options given below :

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

47. **Given below are two statements labelled as Assertion (A) and Reason (R)**

Assertion : In sodium chloride crystal, Na^+ ions occupy octahedral voids while Cl^- ions have *ccp* arrangement.

Reason : The radius ratio of $Na^+ : Cl^-$ lies between 0.4 and 0.7.

Select the most appropriate answer from the options given below :

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

48. Given below are two statements labelled as Assertion (A) and Reason (R)

Assertion : Nitrogen is unreactive at room temperature but becomes reactive at elevated temperature or in presence of a catalyst.

Reason : In nitrogen molecule there is extensive delocalization of electrons.

Select the most appropriate answer from the options given below :

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

49. Given below are two statements labelled as Assertion (A) and Reason (R)

Assertion : Glucose and fructose are reducing sugars.

Reason : Glucose and fructose contain a free aldehydic and ketonic group adjacent to a >CHOH group respectively.

Select the most appropriate answer from the options given below :

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

SECTION - C

This section consists of 6 multiple choice questions with an overall choice to attempt any 5. In case more than desirable number of questions are attempted, ONLY first 5 will be considered for evaluation.

50. Match the column I with column II and mark the appropriate choice.

	Column I		**Column II**
(A)	XeF_4	(i)	sp^3d^2
(B)	XeF_6	(ii)	sp^3d^3
(C)	$XeOF_2$	(iii)	sp^3d
(D)	XeO_3	(iv)	sp^3

(a) (A) → (i); (B) → (ii); (C) → (iii); (D) → (iv)
(b) (A) → (iv); (B) → (iii); (C) → (ii); (D) → (i)
(c) (A) → (iii); (B) → (iv); (C) → (i); (D) → (ii)
(d) (A) → (ii); (B) → (iii); (C) → (iv); (D) → (i)

51. Which of the following analogies is correct ?

(a) Hexagonal : $a = b \neq c$: : Tetragonal : $a = b = c$
(b) bcc : $Z = 2$: : End-centred : $Z = 4$
(c) NaCl : C.N. = 4 : : ZnS : C.N. = 4
(d) NaCl : Schottky defect : : ZnS : Frenkel defect

52. Complete the following analogy :

A : Non-Super imposable mirror images
B : Optically inactive due to internal compensation

(a) A : Diastereomers B : Racemic mixture
(b) A : Enantiomer B : Racemic mixture
(c) A : Enantiomer B : Meso compound
(d) A : Diastereomers B : Meso compound

Case - I : Read the passage given below and answer the following questions 53-55.

Nucleophilic substitution reactions are of two types; substitution nucleophilic bimolecular (S_N2) and substitution nucleophilic unimolecular (S_N1) depending on molecules taking part in determining the rate of reaction. Reactivity of alkyl halide towards S_N1 and S_N2 reactions depends on various factors such as steric hindrance, stability of intermediate or transition state and polarity of solvent. S_N2 reaction mechanism is favoured mostly by primary alkyl halide then secondary and then tertiary. This order is reversed in case of S_N1 reactions.

53. Which of the following is most reactive towards nucleophilic substitution reaction?

(a) C_6H_5Cl (b) $CH_2=CHCl$
(c) $ClCH_2CH=CH_2$ (d) $CH_3CH=CHCl$

54. The most reactive nucleophile among the following is

(a) CH_3O^- (b) $C_6H_5O^-$
(c) $(CH_3)_2CHO^-$ (d) $(CH_3)_3CO^-$

55. Which of the following is the correct order of decreasing S_N2 reactivity?

(a) $RCH_2X > R_2CHX > R_3CX$
(b) $R_3CX > R_2CHX > RCH_2X$
(c) $R_2CHX > R_3CX > RCH_2X$
(d) $RCH_2X > R_3CX > R_2CHX$

SOLUTIONS

1. (b) : $p_{total} = p_A^\circ x_A + p_B^\circ x_B$

$x_A + x_B = 1$ or $x_B = 1 - x_A$

$\therefore \quad p_{total} = p_A^\circ x_A + p_B^\circ(1 - x_A) = p_B^\circ + (p_A^\circ - p_B^\circ)x_A$

2. (a) : No. of A atoms per unit cell

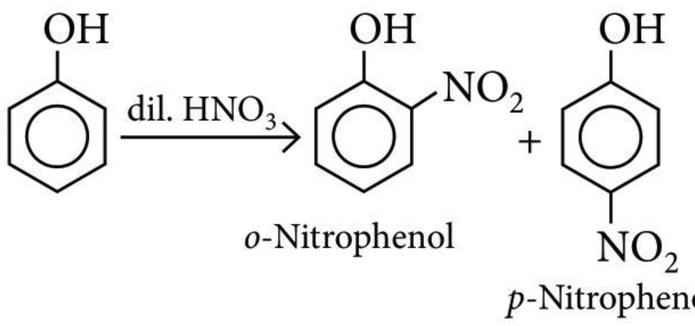
$= 8$ (at corners) $\times \frac{1}{8} = 1$

No. of B atoms per unit cell

$= 6$ (at the face centre) $\times \frac{1}{2} = 3$

So, formula AB_3.

3. (b) :



4. (c) : Peptide linkage is the main structural feature of proteins.

5. (b) : Diaryl ethers are not cleaved by HI.

6. (b) **7. (b)**

8. (d) : $(NH_4)Cr_2O_7 \xrightarrow{\text{Heat}} Cr_2O_3 + N_2 + 4H_2O$

9. (c) : Due to ring formation C_1 of glucose becomes chiral and it yields α- and β-methylglucosides corresponding to α- and β-glucose stereoisomers.

10. (c) : For cane sugar, $\Delta T_f = 273.15 - 271.0 = 2.15°$

$$K_f = \frac{2.15 \times 95 \times 342}{1000 \times 5} = 13.97 \text{ KKg mol}^{-1}$$

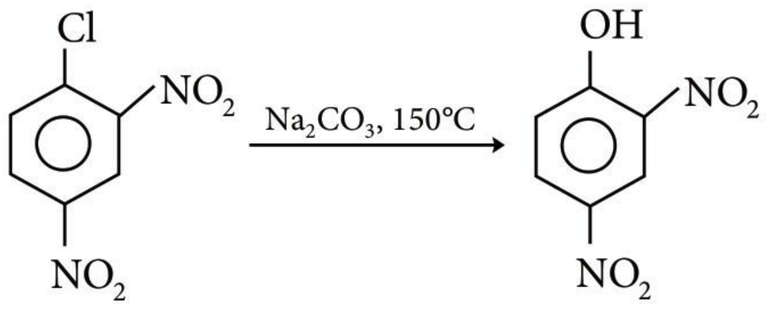
For glucose solution,

$$\Delta T_b = \frac{13.97 \times 1000 \times 5}{95 \times 180} = 4.085 \text{K}$$

$\therefore$ Freezing point = 273.15 – 4.085 = 269.065 K

11. (b)

12. (d) : NO_2 being electron withdrawing group, withdraws electron at *ortho* and *para* positions and thus activates the benzene ring towards nucleophilic substitution.



13. (b) : We know,

$$\rho = \frac{Z \times \text{weight}}{\text{Number of atoms} \times a^3 \times 10^{-30}} \text{ (where, } a \text{ is in pm)}$$

$$\text{Number of atoms} = \frac{2 \times 208}{7.2 \times (288)^3 \times 10^{-30}} \text{ (for } bcc, Z = 2)$$

$$= 24.187 \times 10^{23}.$$

14. (c) : Lower members of alcohols are soluble in water and solubility regularly decreases with molecular mass.

15. (b) : N_2O_3 exists as blue solid at a very low temperature.

16. (c) : $HO - SO_2 - OH + 2PCl_5 \longrightarrow SO_2Cl_2 + 2POCl_3 + 2HCl$

17. (c) : $\pi = \frac{n}{V} RT$

Before dilution, $\frac{500}{760} = \frac{n}{V_1} \times 0.0821 \times 283$ ...(i)

After dilution, $\frac{131.6}{760} = \frac{n}{V_2} \times 0.0821 \times 298$ ...(ii)

Dividing (i) by (ii), $\frac{V_2}{V_1} = \frac{500}{131.6} \times \frac{298}{283} = 4$

$\therefore \quad V_2 = 4V_1$

18. (a)

19. (d) : $R - I > R - Br > R - Cl > R - F$. Lower the $C - X$ bond strength higher is the reactivity.

20. (c) : Triclinic, $a \neq b \neq c$

$\alpha \neq \beta \neq \gamma$

21. (b) : Out of 20 amino acids, only 10 amino acids can be synthesised by human body.

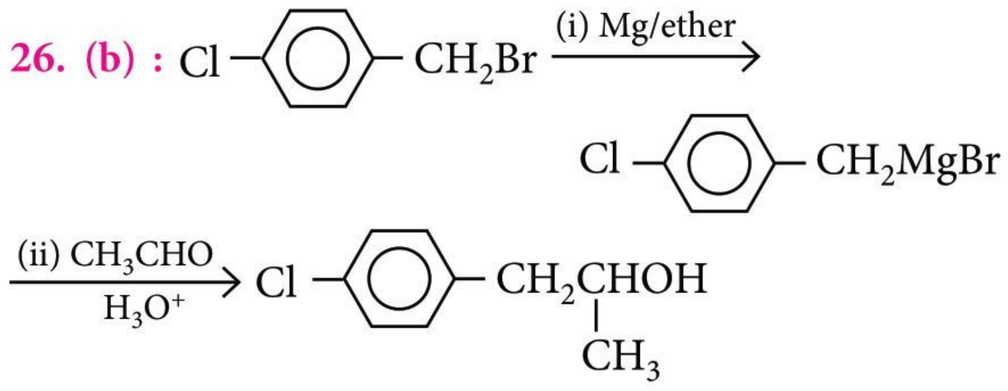
22. (d) : $\underset{\text{Slaked lime}}{2Ca(OH)_2} + 2Cl_2 \longrightarrow \underset{\text{Bleaching powder}}{CaOCl_2} + 2H_2O + CaCl_2$

23. (a) : Both liquid and solid phase of solvent are at equilibrium and both have same vapour pressure.

24. (d) : Formation of di-*tertiary*-butyl ether requires the reaction of sodium *t*-butoxide with *t*-butyl halide. But tertiary alkyl halides prefer to undergo elimination reaction rather than Williamson's reaction in presence of alkoxide ion.

25. (c) : Ribose is a pentose sugar and thus contains only five carbon atoms.

26. (b) :

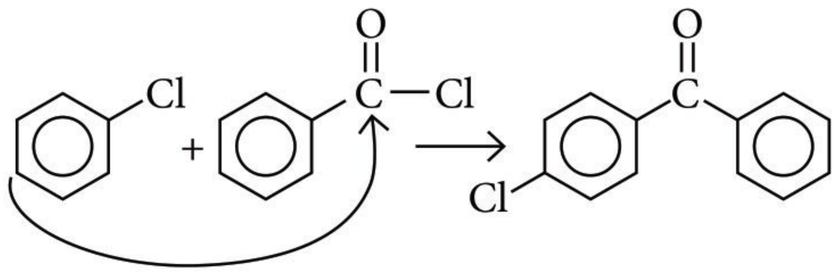


C—Br is more reactive than benzylic C—Cl.

27. (b) : Isoelectric point is the pH at which structure of amino acid has equal positive and negative charges. At this point, the amino acids do not migrate in an electric field.

28. (c) : Due to three $-NO_2$ group (EWG) it increases the polarity of O–H bond and stabilises the phenoxide ions.

29. (c) :



30. (c)

31. (a) : Molecular mass of compound = 180

Molecular mass after acetylation = 390

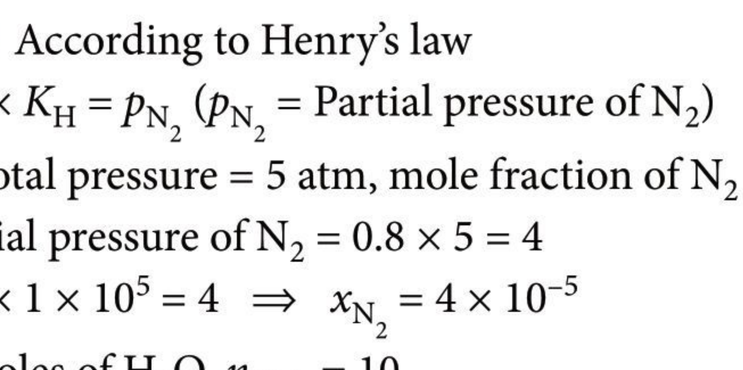
Increase in molecular mass = 210

$$R{-}NH_2 + CH_3{-}\overset{\overset{O}{\|}}{C}{-}Cl \longrightarrow R{-}NH{-}\overset{\overset{O}{\|}}{C}{-}CH_3 + HCl$$

Increase in molecular mass for one $-NH_2$ group is 42 so, total 5 amino groups are present in the intial compound.

32. (d) **33. (a)** **34. (d)**

35. (b) :



36. (b) : Because $a\sqrt{2} = 4r \implies a\sqrt{3} = 4r\sqrt{\frac{3}{2}}$

37. (c) : Due to delocalization of electrons on three atoms, the Cl—O bond length decreases.

38. (b) : As the size of the noble gas atoms increases down the group, the polarisation of the electron cloud becomes easier. So, heavier noble gas atoms are easily polarised in polar water. Thus, solubility increases down the group.

39. (a) : According to Henry's law

$x_{N_2} \times K_H = p_{N_2}$ (p_{N_2} = Partial pressure of N_2)

Given, total pressure = 5 atm, mole fraction of N_2 = 0.8

$\therefore$ partial pressure of $N_2 = 0.8 \times 5 = 4$

$\implies x_{N_2} \times 1 \times 10^5 = 4 \implies x_{N_2} = 4 \times 10^{-5}$

no. of moles of H_2O, $n_{H_2O} = 10$

no. of moles of N_2, $n_{N_2} = ?$

$$\frac{n_{N_2}}{n_{N_2} + n_{H_2O}} = x_{N_2} \implies \frac{n_{N_2}}{10 + n_{N_2}} = 4 \times 10^{-5}$$

$\implies n_{N_2} = 4 \times 10^{-4}$ ($\because n_{N_2} <<<< 10$)

40. (d) : H—S bond is weaker than H—O bond thus, H_2S has higher tendency to release proton.

41. (a) :

$$\underset{(X)}{2C_2H_5OH} \xrightarrow[\text{conc. } H_2SO_4]{413\ K} \underset{(Y)}{C_2H_5OC_2H_5}$$

$$\xrightarrow[\text{under pressure}]{\text{dil. } H_2SO_4/\Delta} \underset{(Z)}{2C_2H_5OH}$$

42. (d) : Nucleophilicity (in DMF) : $CH_3O^- > CH_3S^-$

43. (a) : *fcc* unit cell length = 3.5 Å

bcc unit cell length = 3.0 Å

$$\text{Density} = \frac{Z \times \text{at. wt.}}{V \times \text{Av. no.}}$$

$$\frac{d_{fcc}}{d_{bcc}} = \frac{Z_1}{Z_2} \times \frac{V_2}{V_1}$$

Now, Z_1 for *fcc* = 4 ; Also, $V_1 = a^3 = (3.5 \times 10^{-8})^3$

Z_2 for *bcc* = 2 ; Also, $V_2 = a^3 = (3.0 \times 10^{-8})^3$

$$\frac{d_{fcc}}{d_{bcc}} = \frac{4 \times (3.0 \times 10^{-8})^3}{2 \times (3.5 \times 10^{-8})^3} = 1.259$$

44. (d) : Brown colour of HNO_3 can be removed by passing air through warm acid.

45. (a)

46. (c) : S_N2 reactions are faster in aprotic solvents like DMSO.

47. (a) **48. (c)**

49. (a) : Reducing sugars contain a free aldehydic or ketonic group adjacent to a $>$CHOH group and reduce Tollen's reagent, Schiff's reagent or Benedict's solution.

50. (a)

51. (d) : Tetragonal : $a = b \neq c$

End - centred : $Z = 2$

NaCl : C.N. = 6

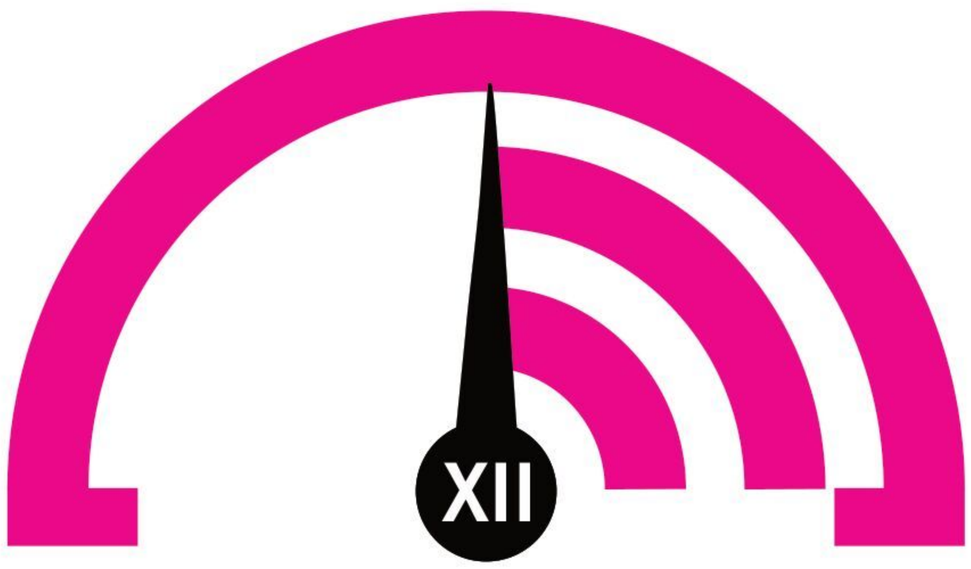
52. (c) : Non-super imposable mirror images are known as enantiomers. The compounds with two or more even number of chiral carbon atoms are optically inactive due to internal compensation, these are known as meso compounds.

53. (c) : Allylic chlorides are most reactive.

54. (a) : Smaller the size of the nucleophile (*i.e.*, CH_3O^-), more reactive it is.

55. (a) : Larger the number of alkyl groups at α-carbon atom, more is the stearic hindrance and hence lesser the reactivity towards S_N2 mechanism.

MONTHLY TEST DRIVE



This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120 **Organic Compounds Containing Nitrogen | Biomolecules** **Time Taken : 60 Min.**

NEET

Only One Option Correct Type

1. A compound *Z* reacts with three moles of CH_3I and gives a product which on hydrolysis gives $[(CH_3)_4N]^+OH^-$. Compound *Z* is
(a) CH_3NH_2 (b) $(CH_3)_2NH$
(c) $(CH_3)_3N$ (d) $(CH_3)_4N^+Cl^-$

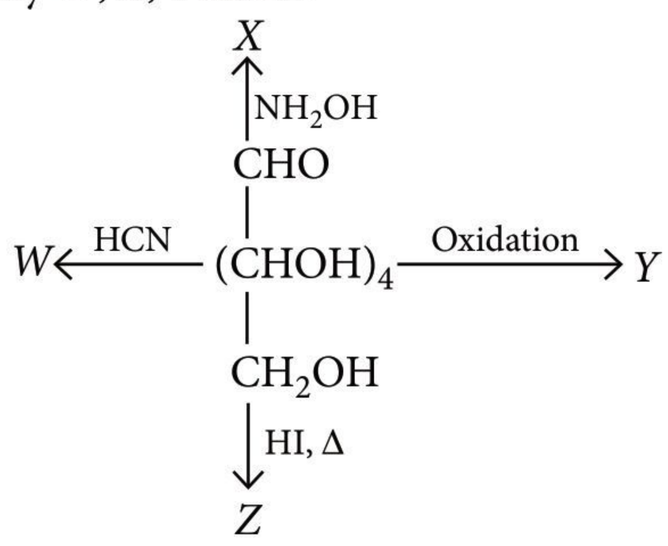
2. α-*D*-Glucose and β-*D*-glucose differ from each other due to difference in one carbon with respect to its
(a) size of hemiacetal ring
(b) number of OH groups
(c) configuration
(d) conformation.

3. Acetanilide on nitration followed by alkaline hydrolysis mainly gives
(a) *o*-nitroacetanilide (b) *p*-nitroaniline
(c) *m*-nitroaniline (d) 2,4,6-trinitroaniline.

4. Which statement is incorrect about peptide bond?
(a) C–N bond length in proteins is longer than usual bond length of C–N bond.
(b) Spectroscopic analysis shows planar structure of $-\overset{\overset{O}{\|}}{C}-NH-$ bond.
(c) C – N bond length in proteins is smaller than usual bond length of C – N bond.
(d) None of these.

5. The correct order of increasing basicity in aqueous solution is
(a) $NH_3 < C_6H_5NH_2 < (C_2H_5)_2NH < C_2H_5NH_2 < (C_2H_5)_3N$
(b) $C_6H_5NH_2 < NH_3 < (C_2H_5)_3N < C_2H_5NH_2 < (C_2H_5)_2NH$
(c) $C_6H_5NH_2 < NH_3 < C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$
(d) none of the above.

6. Identify *W*, *X*, *Y* and *Z*.



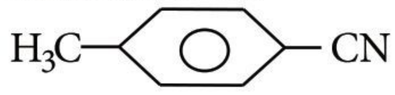
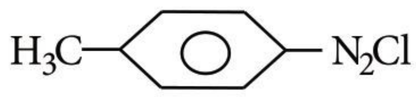
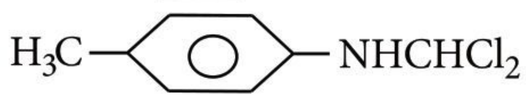
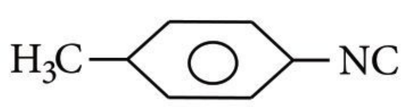
	W	*X*	*Y*	*Z*
(a)	*n*-Hexane	Saccharic acid	Glucose oxime	Glucose cyanohydrin
(b)	Saccharic acid	Glucose oxime	*n*-Hexane	Glucose cyanohydrin
(c)	Glucose cyanohydrin	Glucose oxime	Saccharic acid	*n*-Hexane
(d)	Glucose oxime	Saccharic acid	Glucose cyanohydrin	*n*-Hexane

7. A compound '*A*' has a molecular formula C_7H_7NO. On treatment with Br_2 and KOH, '*A*' gives an amine '*B*' which gives carbylamine test. '*B*' upon diazotisation and coupling with phenol gives an azo dye. '*A*' can be
(a) $C_6H_5CONHCOCH_3$
(b) $C_6H_5CONH_2$
(c) $C_6H_5NO_2$
(d) *o*-, *m*- or *p*-$C_6H_4(NH_2)CHO$.

8. In both DNA and RNA, heterocyclic base and phosphate ester linkages are at
(a) C_5' and C_2' respectively of the sugar molecule
(b) C_2' and C_5' respectively of the sugar molecule
(c) C_1' and C_5' respectively of the sugar molecule
(d) C_5' and C_1' respectively of the sugar molecule.

9. The indicator that is obtained by coupling the diazonium salt of sulphanilic acid with *N*, *N*-dimethylaniline is
(a) phenanthroline (b) methyl orange
(c) methyl red (d) phenolphthalein.

10. In polysaccharides, the linkage connecting monosaccharides is called
(a) glycosidic linkage (b) nucleoside linkage
(c) glycogen linkage (d) peptide linkage.

11. The reaction of chloroform with alcoholic KOH and *p* -toluidine forms
(a) 
(b) 
(c) 
(d) 

12. Which of the following is/are protein hormones?
(a) Insulin (b) Estradiol
(c) Oxytocin (d) both (a) and (c)

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** On reduction of acetamide with $LiAlH_4$ we can obtain secondary amine easily.
Reason : Secondary amine has general formula *R*CONH*R*.

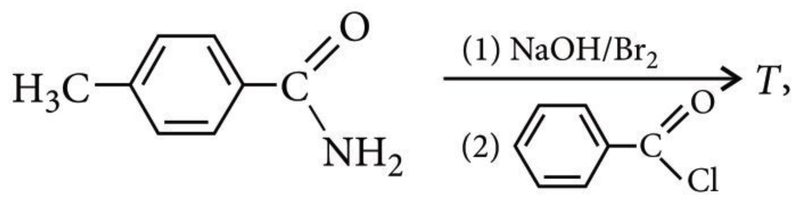
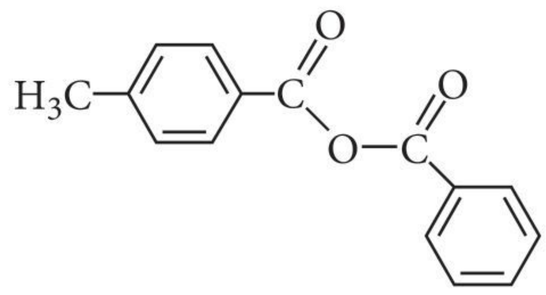
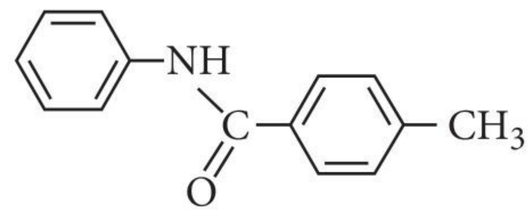
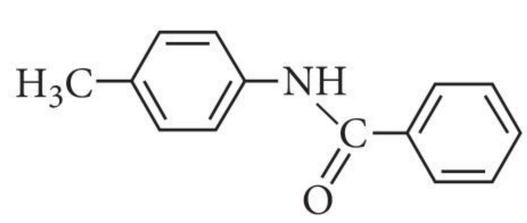
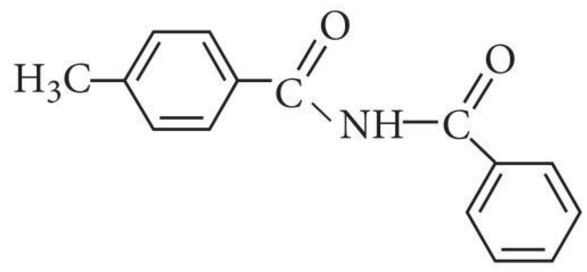
14. **Assertion :** An aqueous solution of glycine of pH = 7 is not electrically neutral.
Reason : The isoelectric point of glycine, pI is 6.0.

15. **Assertion :** Nitriles on reduction with lithium aluminium hydride or catalytic hydrogenation produce primary amines.
Reason : The amides on reduction with $LiAlH_4$ yield amines.

JEE MAIN / JEE ADVANCED

Only One Option Correct Type

16. Which reaction sequence would be best to prepare 3-chloroaniline from benzene?
(a) Chlorination, nitration, reduction.
(b) Nitration, chlorination, reduction.
(c) Nitration, reduction, chlorination.
(d) Nitration, reduction, acetylation, chlorination, hydrolysis.

17. In the reaction

the structure of the product *T* is
(a) 
(b) 
(c) 
(d) 

18. Which of the following are non-reducing sugar molecules?
(i) Fructose (ii) Maltose
(iii) Sucrose (iv) Lactose
(a) (i) and (iii) (b) (i) and (iv)
(c) (iii) only (d) (i) and (ii)

19. If corn is immersed in the boiling water and then cooled, the solution becomes sweet. It is due to
(a) enzymes are inactivated in boiling water
(b) disaccharides are converted to monosaccharides
(c) monosaccharides are converted to disaccharides
(d) none of these.

More than One Options Correct Type

20. For 'invert sugar', the correct statement(s) are (Given : specific rotations of (+)-sucrose, (+)-maltose, *L*-(–)-glucose and *L*-(+)-fructose in aqueous solution are +66°, +140°, –52° and +92°, respectively)

(a) 'invert sugar' is prepared by acid catalyzed hydrolysis of maltose

(b) 'invert sugar' is an equimolar mixture of *D*-(+)-glucose and *D*-(–)-fructose

(c) specific rotation of 'invert sugar' is –20°

(d) on reaction with Br_2 water, 'invert sugar' forms saccharic acid as one of the products.

21. The reduction of benzenediazonium chloride to phenyl hydrazine can be accomplished by

(a) $SnCl_2$, HCl (b) Na_2SO_3

(c) CH_3CH_2OH (d) H_3PO_2

22. Which of the following are important secondary structural feature in large peptides and proteins?

(a) The α-helix

(b) Regular folding of the backbone of the polypeptide chain

(c) Hydrogen bonding

(d) The β-pleated sheet

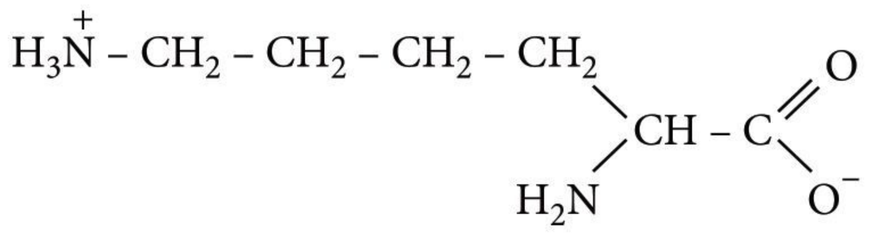
23. Identify the compounds from the following which form primary amines under suitable reduction conditions.

(a) C_2H_5CN (b) C_2H_6

(c) $C_2H_5CONH_2$ (d) $C_6H_5NO_2$

Integer / Numerical Value Type

24. The total number of basic groups in the following form of lysine is_____.



25. Total number of structural isomers of 3°-amines possible for $C_6H_{15}N$ is _____.

26. Polypeptides with fewer amino acids are likely to be called proteins if they ordinarily have a well defined conformation of a protein such as insulin which contains *n* amino acids. The value of *n* is _____.

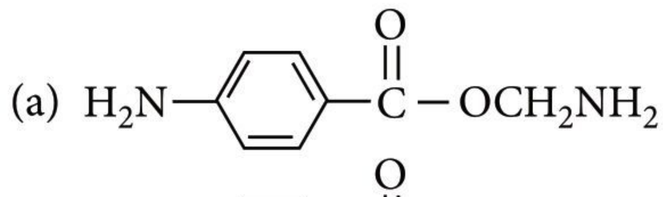
Comprehension Type

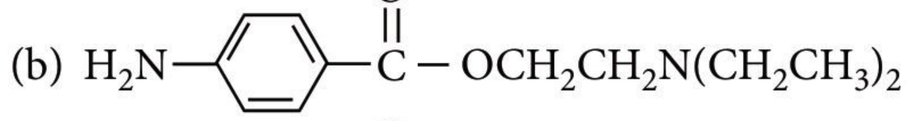
Novocaine, a local anaesthetic, is a compound with molecular formula, $C_{13}H_{20}O_2N_2$. It is insoluble in water and dilute NaOH, but soluble in dil. HCl. Upon treatment with $NaNO_2$ and HCl and then with β-naphthol, a highly coloured solid is formed. When Novocaine is boiled with aqueous NaOH, it slowly dissolves. The alkaline solution is shaken with ether and layers are separated.

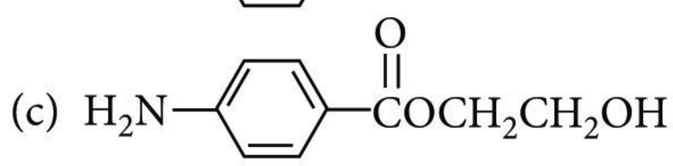
Acidification of the aqueous layer causes the precipitation of white solid '*A*'; continued addition of acid causes '*A*' to redissolve. Upon isolation '*A*' is found to have melting point of 185-186°C and the formula $C_7H_7O_2N$.

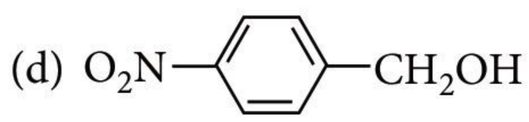
Evaporation of ether layer leaves a liquid '*B*' of formula $C_6H_{15}ON$. '*B*' dissolves in water to give a solution that turns litmus blue. Treatment of '*B*' with acetic anhydride gives '*C*', $C_8H_{17}O_2N$ which is insoluble in water and dilute bases, but soluble in dilute HCl. '*B*' is found to be identical to the compound formed by the action of diethylamine on ethylene oxide.

27. When compound '*B*' is treated with *p*-nitrobenzoyl chloride followed by moderate reduction with Ni/H_2; the compound formed is

(a) 

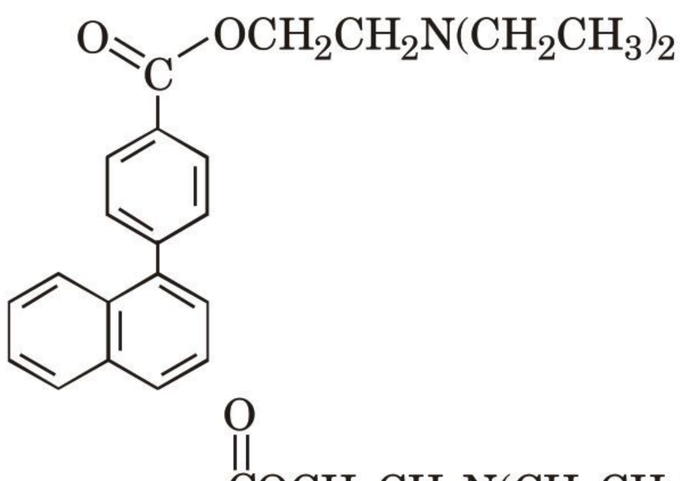
(b) 

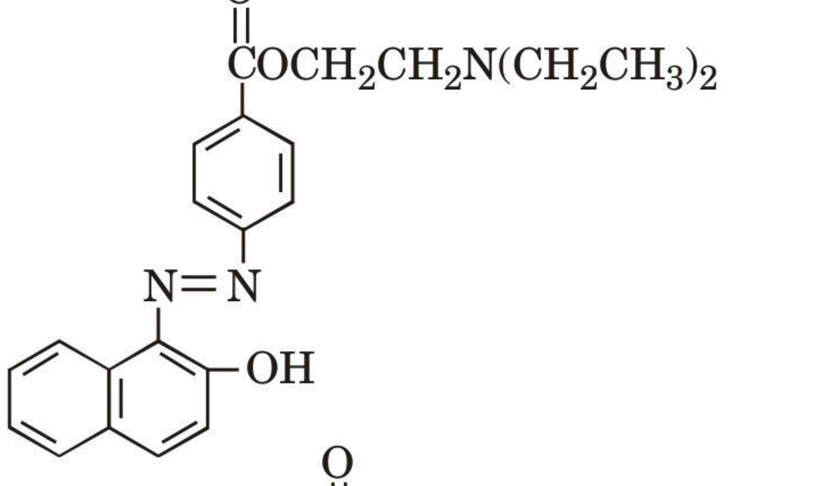
(c) 

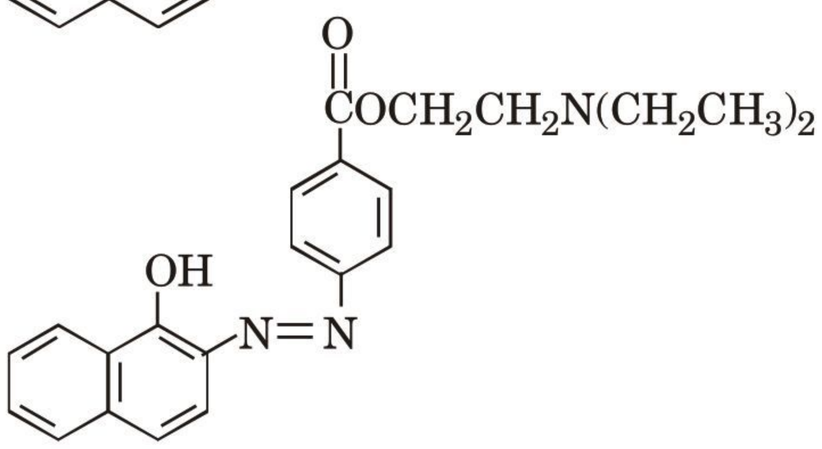
(d) 

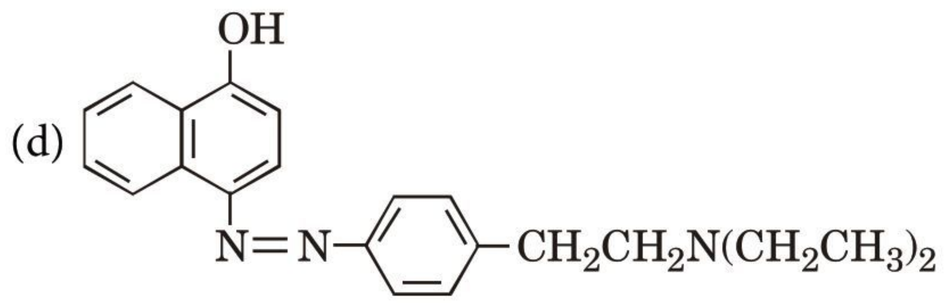
28. Novocaine $\xrightarrow{NaNO_2, HCl}$ *A* $\xrightarrow{\beta\text{-Naphthol}}$ Product

The product is

(a) 

(b) 

(c) 

(d) 

Matrix Match Type

29. Match the List I with List II and select the correct answer using the code given below the lists :

	List I		List II
P.	Aniline	1.	Can be made by Gabriel phthalimide reaction.
Q.	*N*-Methylaniline	2.	Undergoes electrophilic substitution reaction with HNO_2
R.	*N*,*N*-Dimethyl aniline	3.	Forms yellow oily product with HNO_2
S.	Benzylamine	4.	Gives azo dye test

	P	Q	R	S
(a)	4	3	2	1
(b)	2	4	1	3
(c)	3	1	4	2
(d)	1	2	4	3

30. Match the List I with List II and select the correct answer using the code given below the lists :

	List I		List II
P.	Melatonin	1.	Controls body's salt and water balance
Q.	Oxytocin	2.	Stress hormone
R.	Cortisol	3.	Controls sleep and wake cycle
S.	Aldosterone	4.	Helps with lactation, childbirth

	P	Q	R	S
(a)	1	4	2	3
(b)	3	4	2	1
(c)	3	4	1	2
(d)	1	2	4	3

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

Infinity Learn by Sri Chaitanya Educational Institutions X amazon academy unleash the winning edge

Prepare for JEE and NEET with Sri Chaitanya Faculty on Amazon Academy

Swagata Mukherjee	P Shankar	Mani Kumar	Basheer Shaik	Suchita Mukhopadhyay
M.SC. ZOOLOGY	40 YEARS EXP.	IIT KHARAGPUR	15 YEARS EXP.	IIT(ISM), DHANBAD

2020 RESULTS

- **36,547** | NEET Ranks
- **20,904** | JEE Main
- **3,449** | JEE Advanced

Introducing Repeaters Batch
Structured courses and live lectures with experienced Sri Chaitanya and Amazon Academy faculty

All India Mock Tests, Full, Part & Chapter Tests
Know your All India Rank and get detailed performance reports

17,000+ Practice Questions
Learn new problem solving techniques with in-depth solutions

Preparation Strategy Masterclasses
Analyse mock tests, devise preparation plans, stay motivated

FREE COUNSELLING SESSION*

+91 89290 37750

https://academy.amazon.in/

*Amazon Academy Free Counselling Terms and Conditions (available at: https://amzn.to/3yAvWzQ) apply to the counselling sessions offered by Amazon Academy.

GET IT ON Google Play

Registered R.N.I. No. 53544/1991 *Published on 1st of every month* Postal Regd. No. DL-SW-01/4044/21-23
Lic. No. U(SW)-28/2021-23 to post without prepayment of postage LPC Delhi RMS, Delhi-06 on 2-3rd same month